



AP Computer Science Principles

**How Computers Work:
Computer Architecture
and Data Storage**

What You Will Learn

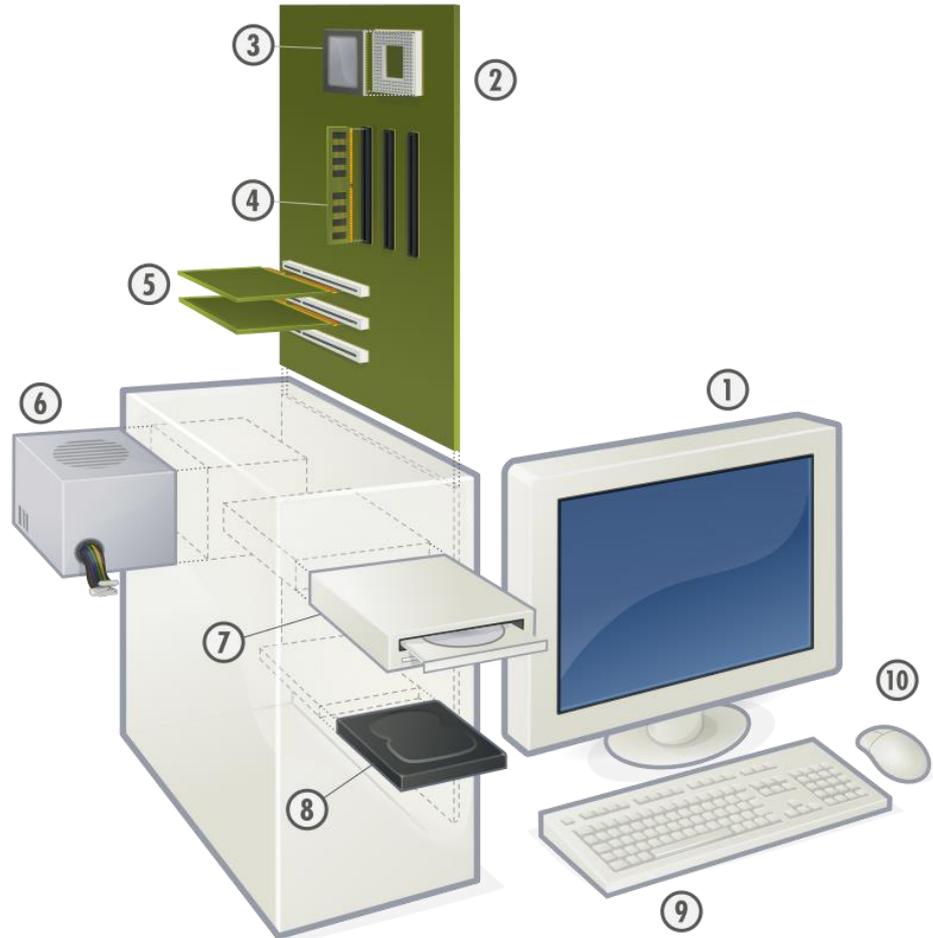
- How to disassemble and rebuild a computer
- How to choose the parts to build a new computer
- Logic Gates
- Data storage:
 - Binary
 - Hexadecimal
 - ASCII
- Data compression
- Computer Forensics
- Limits of computing

Introduction to Computer Hardware

The Parts of a Computer

An exploded view of a modern personal computer:

1. Display
2. Motherboard
3. CPU (Microprocessor)
4. Primary storage (RAM)
5. Expansion cards (graphics cards, etc.)
6. Power supply
7. Optical disc drive
8. Secondary storage (Hard disk)
9. Keyboard
10. Mouse



Main parts of a computer

- Case
- Power supply
- Motherboard
 - CPU
 - RAM
 - Adapter Cards
- Internal and External Drives
- Internal and External Cables

The Motherboard

- The motherboard provides the electrical connections between the computer components.
- Comes in different sizes called “form factors.”
- All the other components of the computer connect to the motherboard directly or through a cable.



A Case Needs to be a Form Factor as Larger or Larger than the Motherboard.

Name	size (mm)
BTX	325 × 266
ATX	305 × 244
EATX (Extended)	305 × 330
LPX	330 × 229
microBTX	264 × 267
microATX	244 × 244
Mini-ITX	170 × 170



Standard-ATX



Micro-ATX



Mini-ITX



Nano-ITX



Pico-ITX

The Power Supply

- Power Supplies come in different form factors and should match the form factor of the case.
- Power supplies are rated in watts and should have a rating larger than the total required watts of all the computer components.



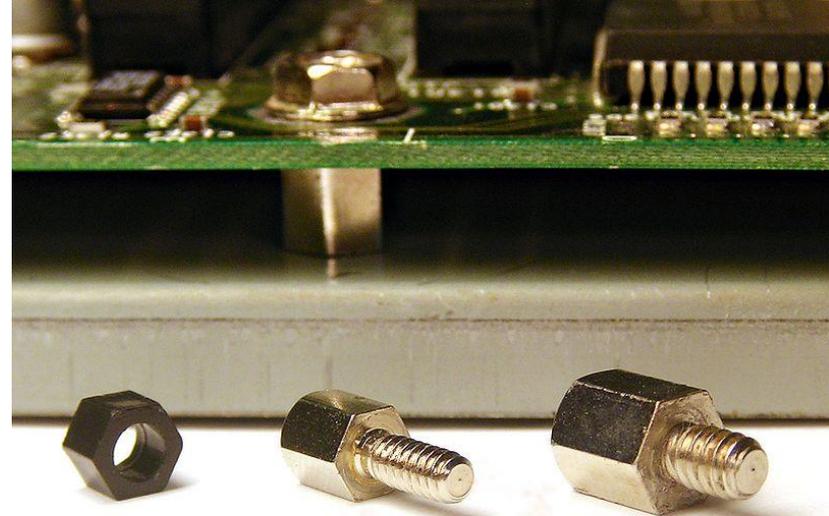
The Power Supply Connectors

- The Power Supply will have lots of extra connectors so you can add additional components to your computer at a later time.



Motherboard Stand Offs

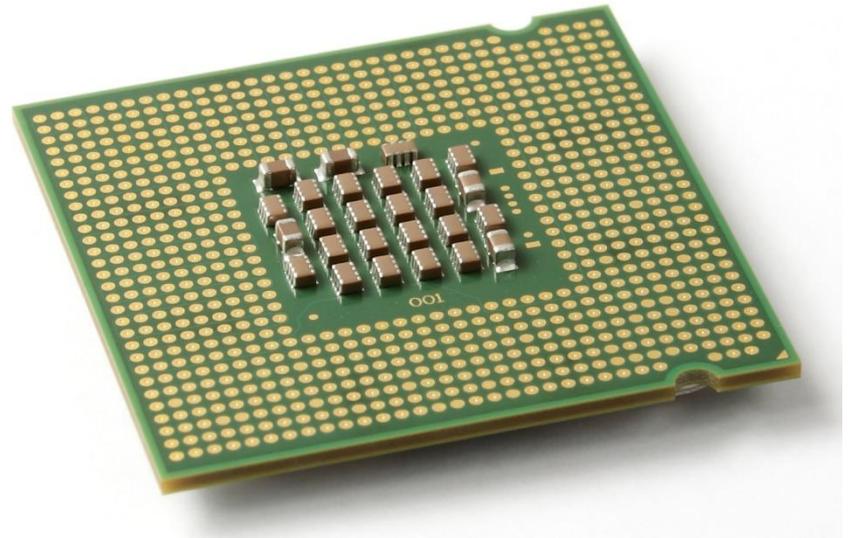
- If the electrical circuits on the motherboard were to contact the metal case it would create a "short."
- Stand offs raise the motherboard so it doesn't touch the case.



The Parts of a Computer

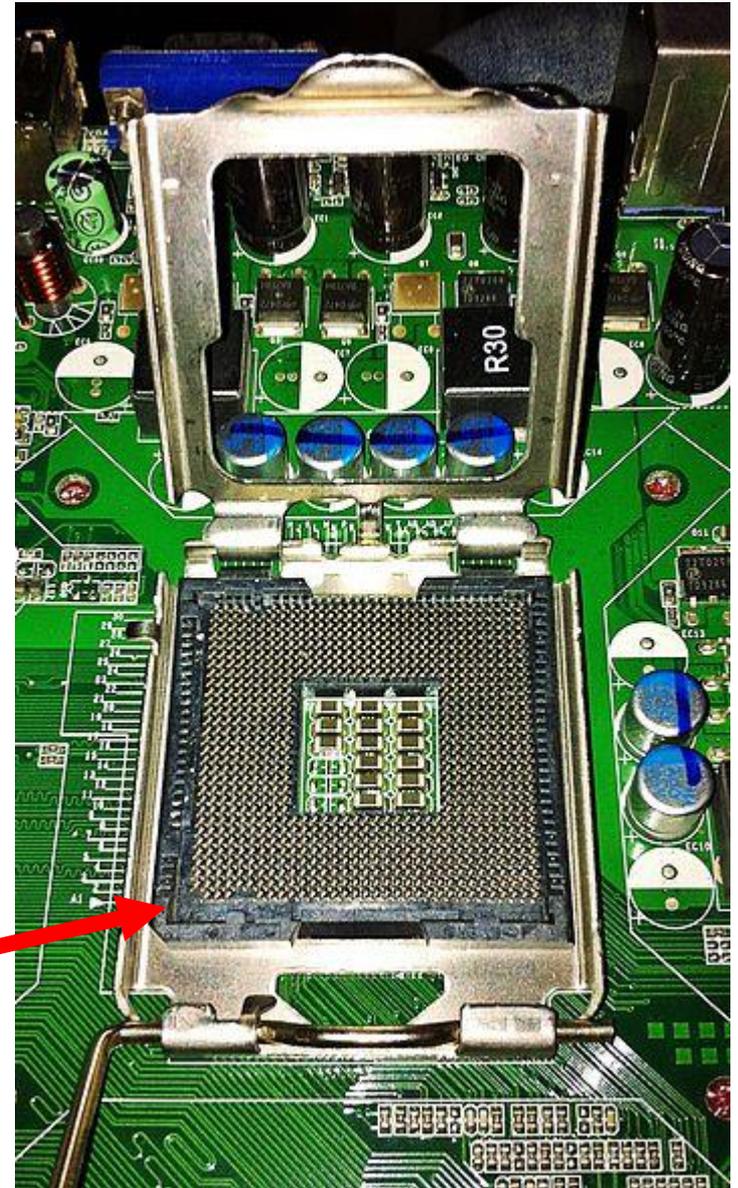
- CPU—Central Processing Unit or Processor
- Executes logical instructions like math and sends out the result.

The speed of the CPU and the amount of RAM are the two biggest factors that effect computer performance



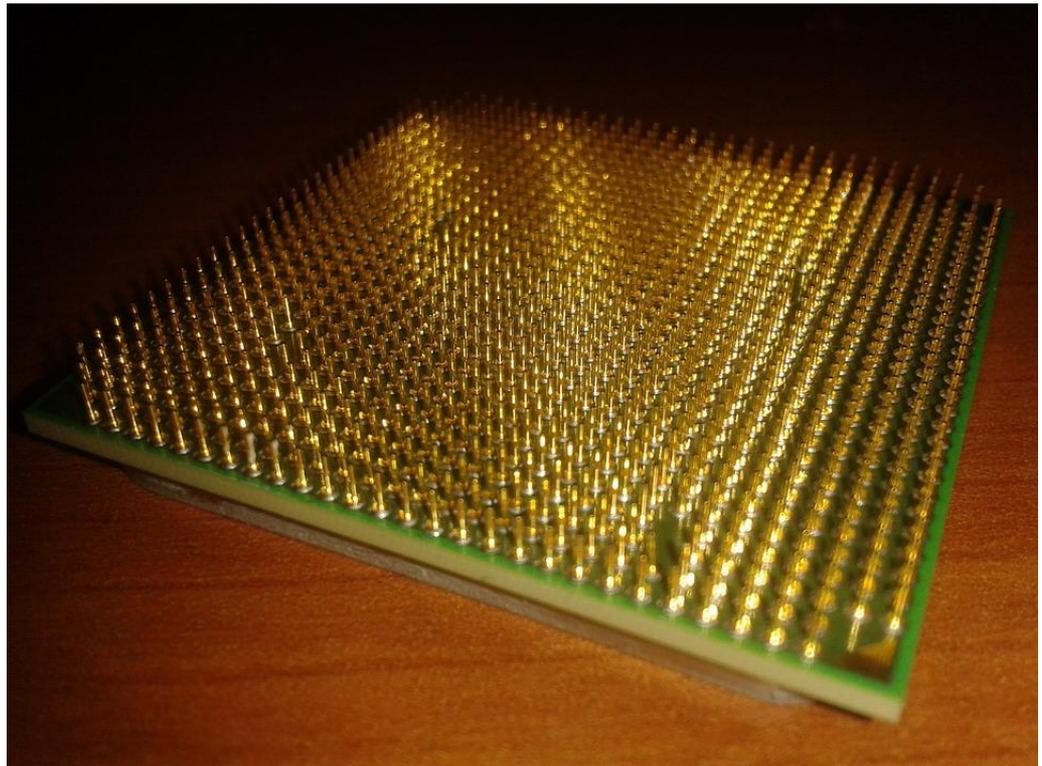
CPU Alignment

- CPUs use sockets that connect electrically with metal pins.
- One corner of both the socket and CPU will be different to indicate it is Pin 1.
- Align Pin 1 on the CPU with Pin 1 on the socket



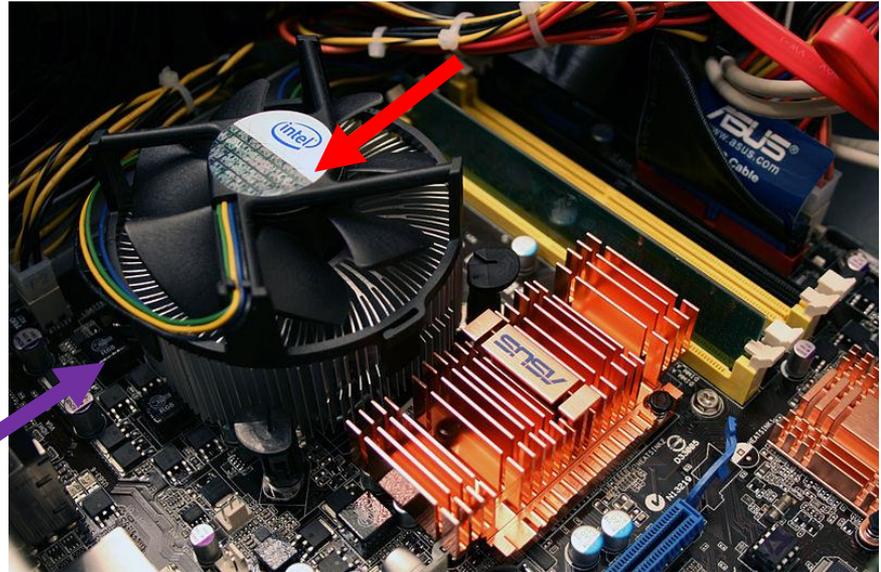
The Worst Assembly Mistake!

- Watch out! The CPU is fastened to the motherboard with a **lever** that presses the CPU into its **socket**.
- If the CPU is crooked, pushing the **lever** will **break the pins** on the CPU and/or the socket.



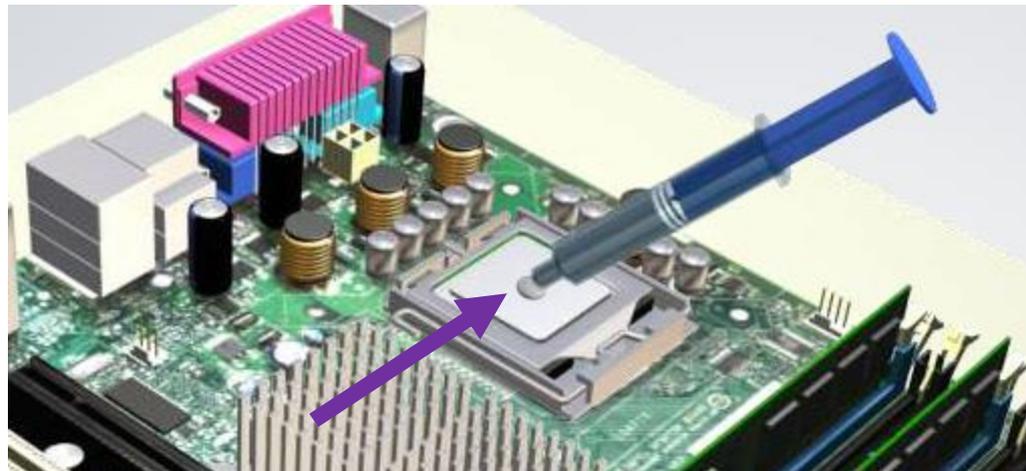
CPUs Generate Heat and Need to be Cooled

- It's important to keep a CPU cool.
- CPU typically have a large piece of metal called a **heat sink** and **fan** to keep them cool.



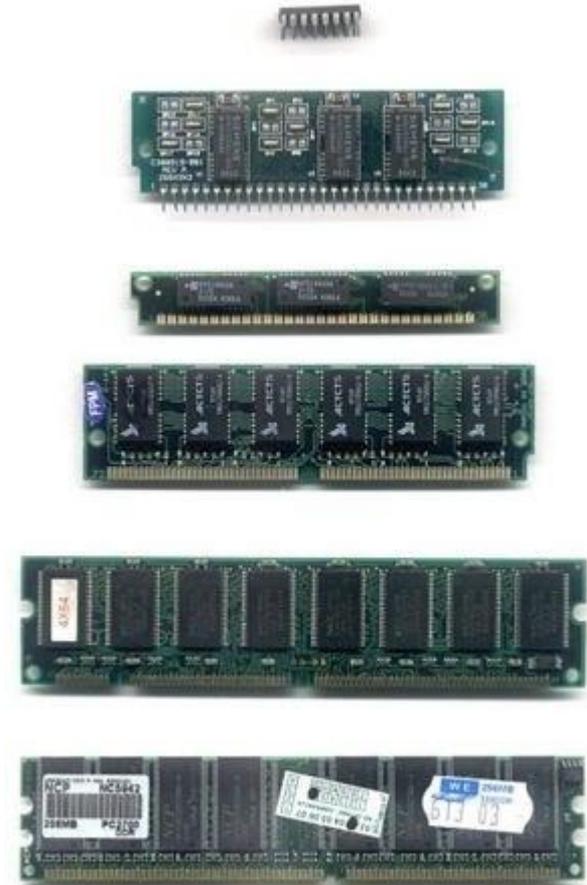
Thermal Compound (also called Thermal Paste or Grease)

- A **small amount of thermal compound** is used to fill the microscopic gaps between the CPU and the heat sink so that the heat moves away from the CPU to the heat sink.



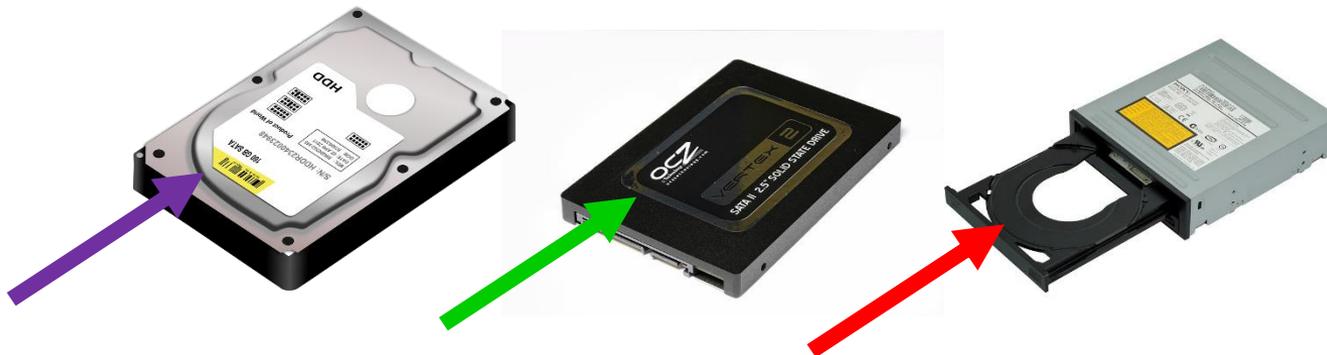
Volatile Memory RAM

- Comes in different varieties and sizes.
- Use the motherboard manufacturer website to choose compatible RAM
- RAM is ***volatile***.
- That means all data in RAM is lost when the power is turned off.



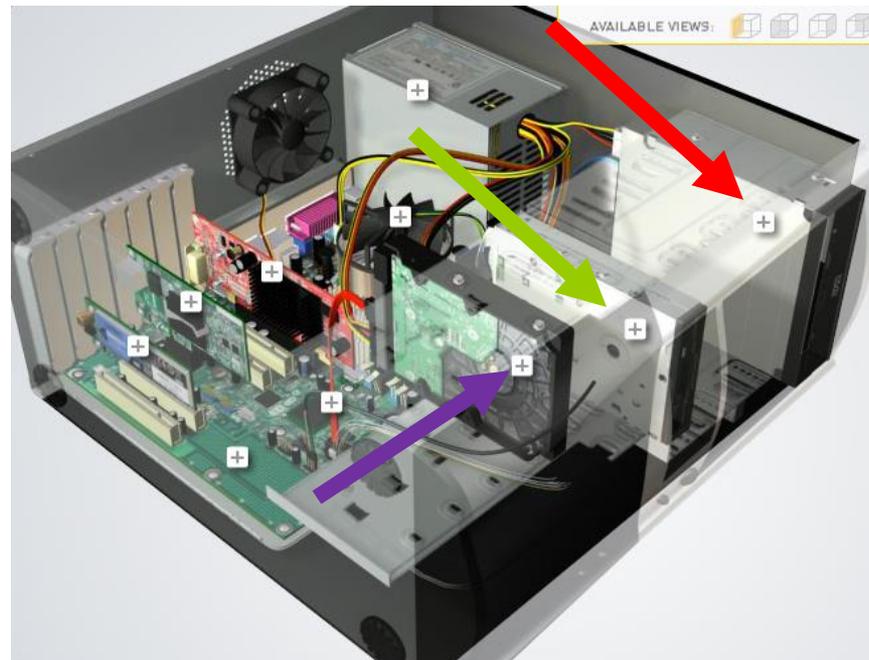
Internal and External Drives: Non-volatile Storage

- Your computer will need some form of non-volatile storage.
- Some combination of **hard drives** (HHD), **solid state drives** (SSD), flash memory, **optical drives** and/or floppy drives.



Internal and External Drives

- Internal Drives (**hard drives** and SSDs) store the operating system and other files.
- External Drives (**DVD, CD** and **floppy**) are used to transfer files to and from the internal drives.
- External drives have been largely replaced by thumb drives.



Ports and Cables

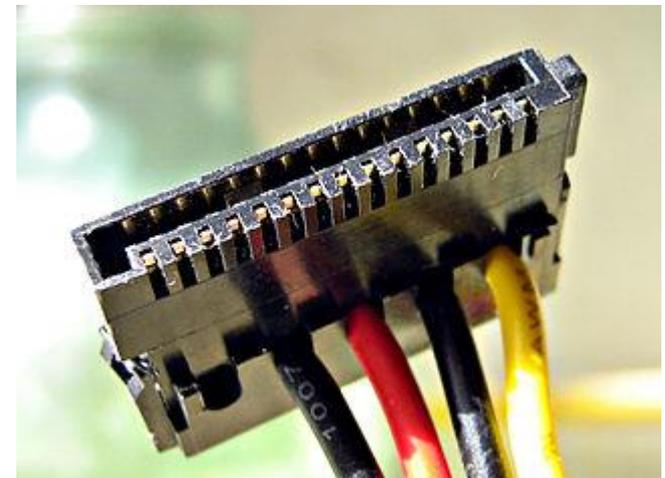
- There are many cables on both the inside and outside of a computer.
- Every cable plugs into a matching receptacle or *port*.
- The cables carry *data*, electrical *power* or both.
- The different port types are designed to minimize the possibility of plugging in a cable in the wrong way.

Internal Cables

- Internal data cables connect directly to the motherboard
- Internal power cables connect directly to the power supply

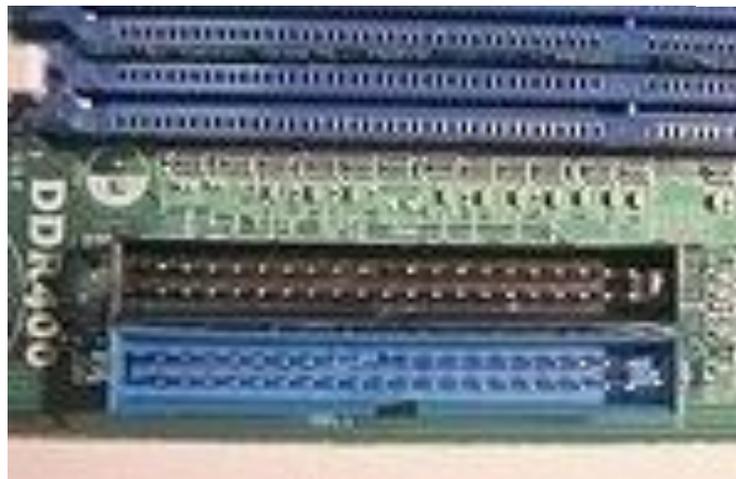
SATA Internal Power and Data Cables

- Data and power connectors for newer hard drives and CD/DVD drives.
- The smaller 7 pin cable is for data and the larger 15 pin cable is for power.



PATA Internal Data Cable

- Also called IDE.
- Data connection for hard drives, CD or DVD optical drives.



Internal cables: PATA and SATA

- Older drives use a flat ribbon PATA data cable to the motherboard and 4 pin white power connector
- Newer drives use the black SATA connectors

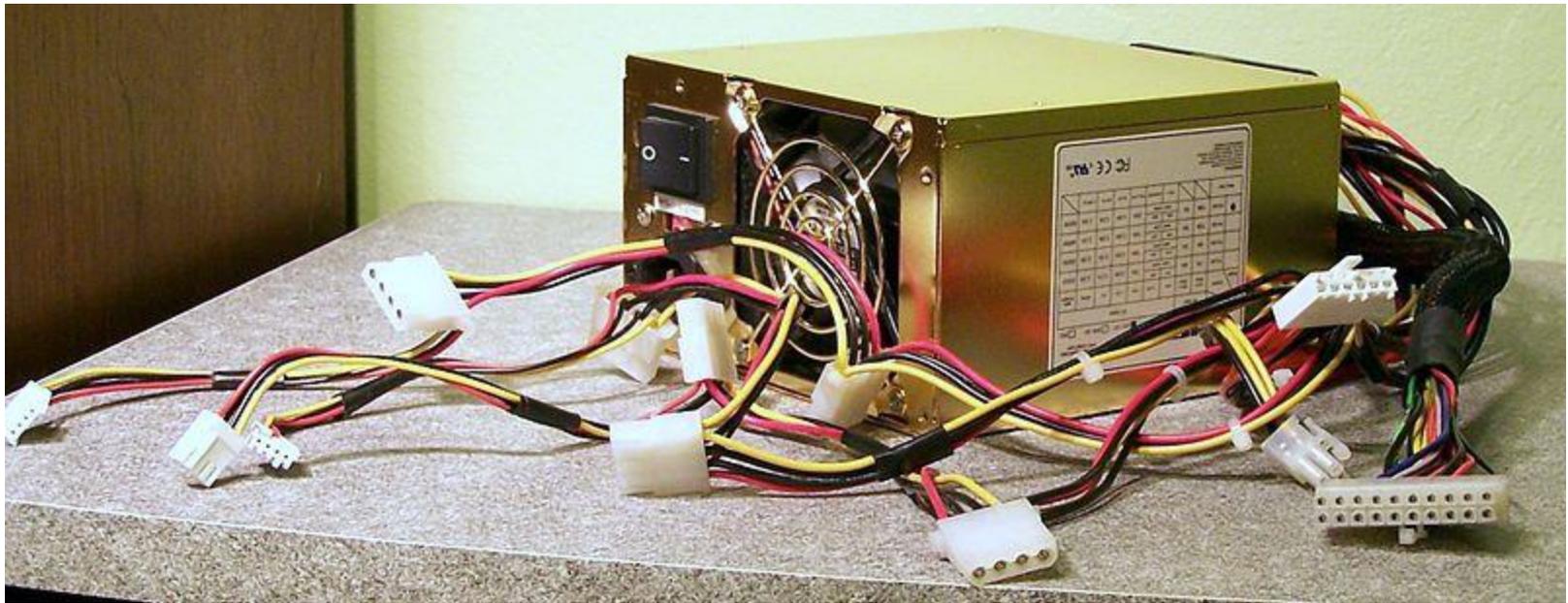


Floppy Data Cable



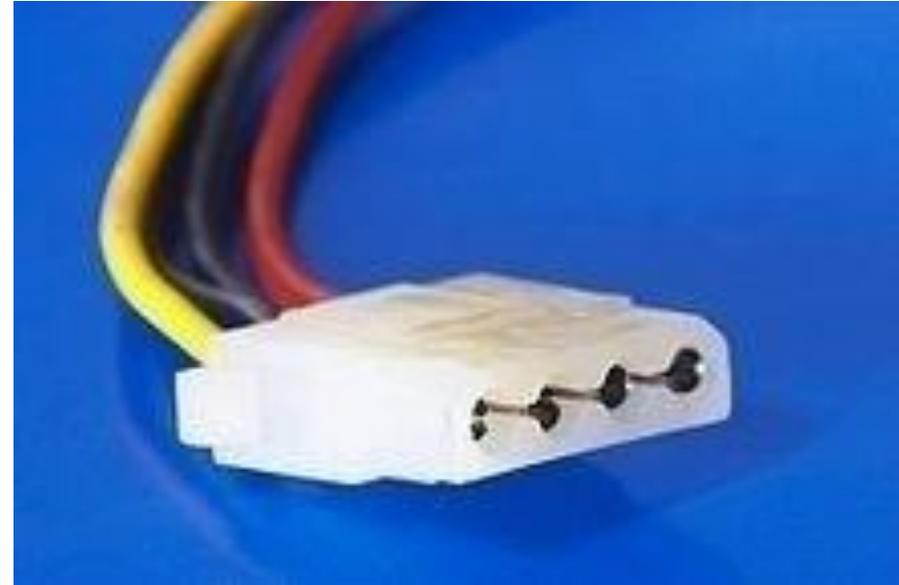
- Looks like a PATA cable, but it's smaller with a twist.

The Power Supply Has Many Different Internal Power Cables



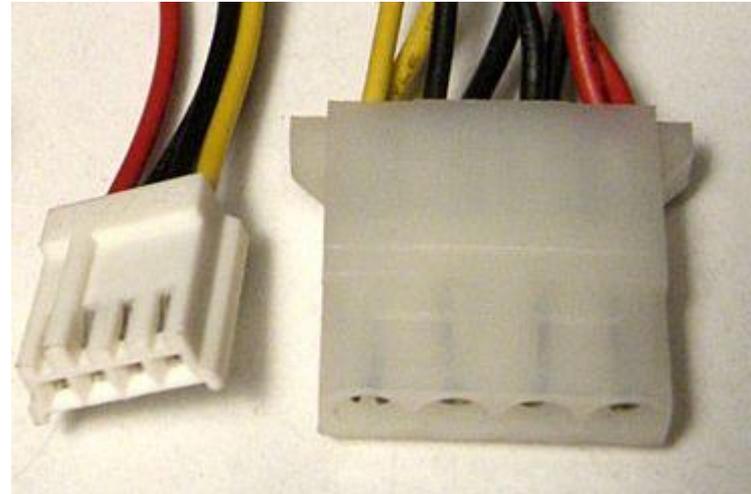
Molex

- Power connector used with older PATA hard drives and optical DVD drives.



Berg

- Power connector used for floppy drives.
- **Berg** connectors are much smaller than **Molex**.

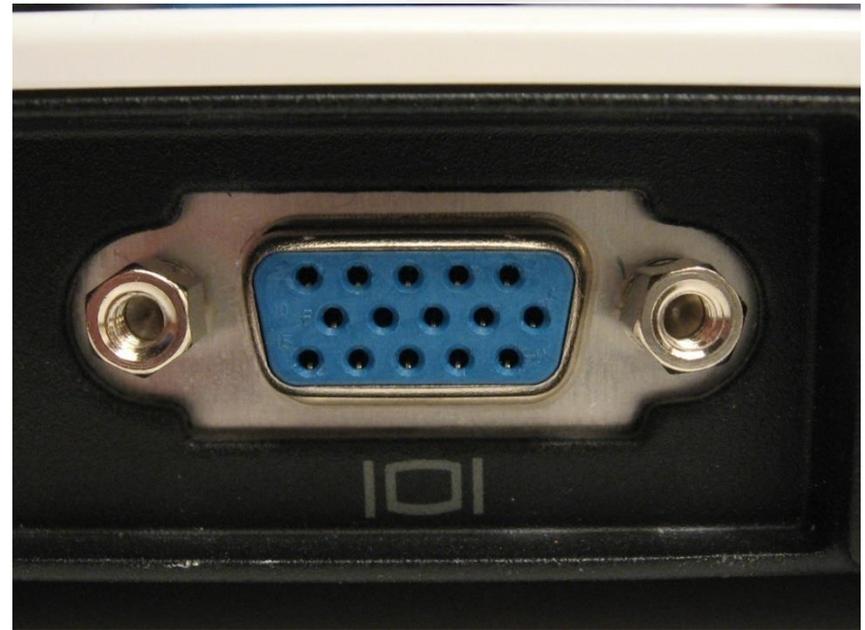


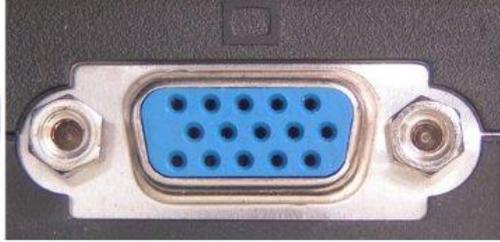
External Cables

- External cables connect to the front or back of the computer case

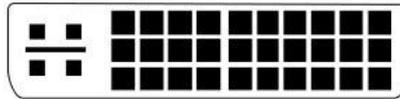
VGA

- Most common type of cable that connects a monitor to a computer.

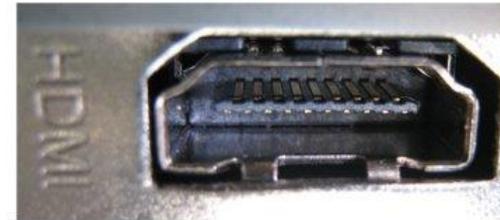




VGA



DVI



HDMI

- HDMI is a digital **audio** and video connection and can connect to a TV.
- VGA is analog video only.
- DVI is digital/analog video only.
- If both your monitor and video card support it DVI is preferable to VGA.

USB

- Very common cable used to connect other devices to the computer.
- “Hot swappable” no need to power off the computer to disconnect or reconnect.
- Power and Data
- Max 5m (16.4 ft)



Network Interface Cards Use an External Ethernet Cable

- Ethernet is the connector for connecting to a wired network.
- Ethernet cables use an **RJ45 connector**.
- Ethernet cables are sometimes confused with **telephone cables** even though they are twice as big.



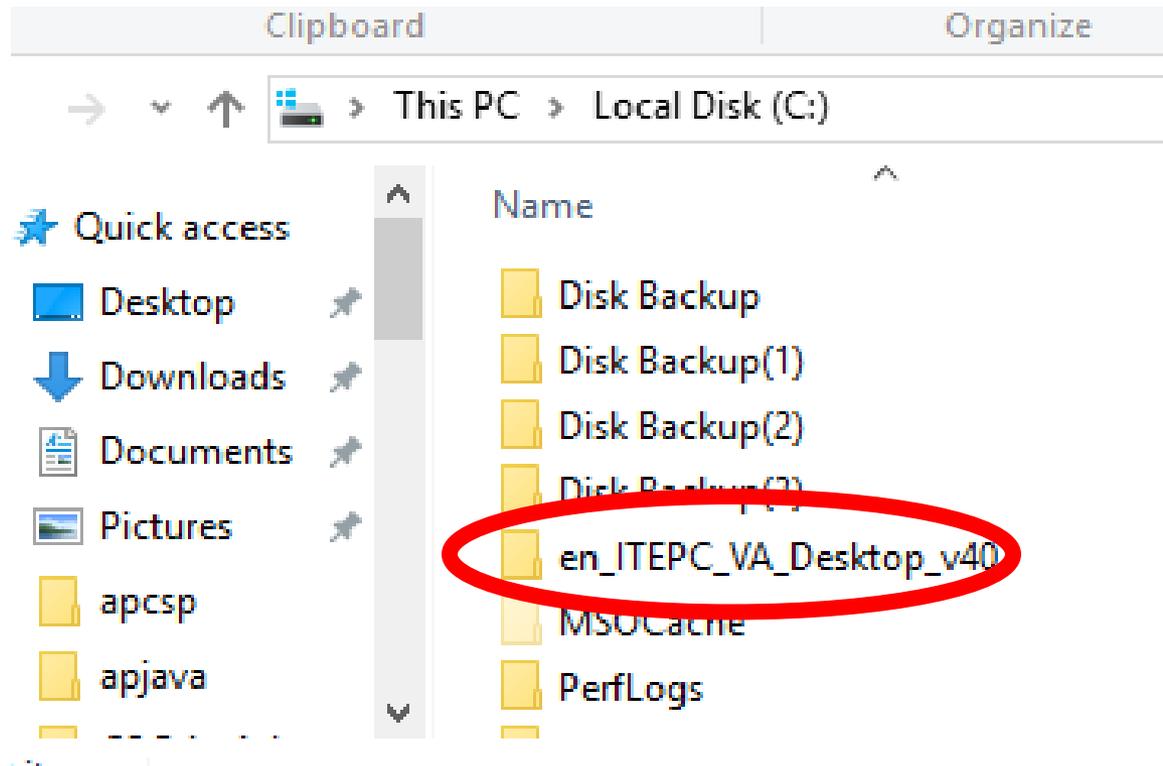
Input Devices that Connect Through External Cables

- Biometric
- Digital Cameras
- Capture Card
- Scanner
- Keyboard
- TV Tuner
- Microphone
- Tablet
- Touchscreen

Output Devices that Connect Through External Cables

- Monitor
- Speakers
- Headphones
- Printer
- LCD projector

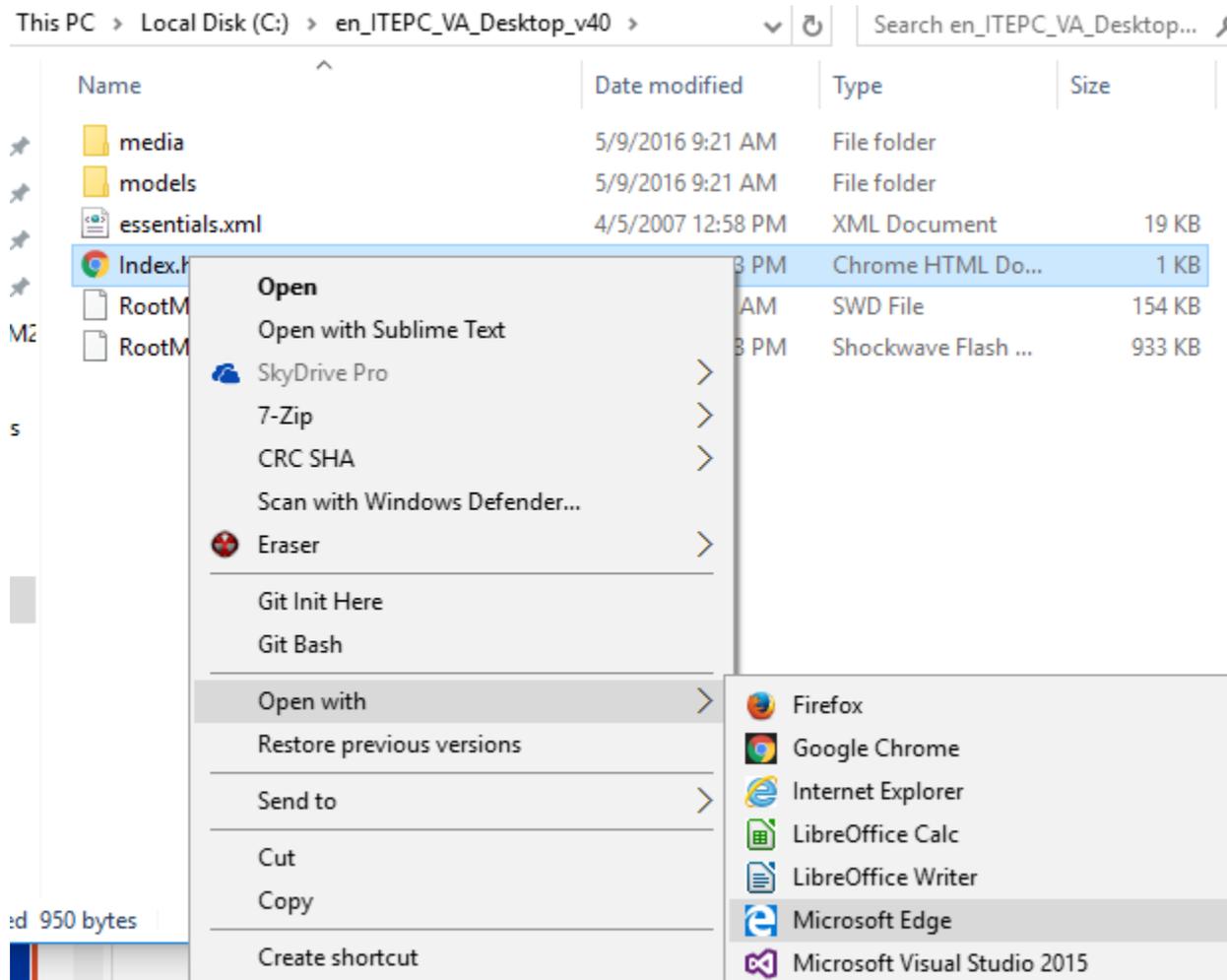
The Virtual Desktop Lab Simulates Assembling a PC



- Navigate to *Local Disk C:* and open the folder **en ITEPC_VA_Desktop_v40**

Virtual Desktop Lab

- Right click on **index.html** and choose *Open with | Microsoft Edge*



Virtual Desktop Lab

- Use the right arrow to take a quick tour.
- If prompted choose *Allow Blocked Content*.

The screenshot displays the 'IT Essentials Virtual Desktop' interface within a browser window. The address bar shows the file path: file:///C:/en ITEPC_VA_Desktop_v40/Index.html. The page title is 'IT Essentials Virtual Desktop' with a 'Help ?' link. The main content area is titled 'WELCOME TO IT ESSENTIALS VIRTUAL DESKTOP' and includes a 'SKIP' button. The text explains that the virtual desktop is for learning to assemble a desktop computer and offers a 'Show Instructions' button. A sidebar menu lists various components: POWER SUPPLY, MOTHERBOARD (selected), ADAPTER CARDS, INTERNAL DRIVES, DRIVES IN EXTERNAL BAYS, INTERNAL CABLES, EXTERNAL CABLES, TEST, and EXPLORE. The main content area features a 3D isometric view of a motherboard on an 'ANTISTATIC MAT'. A list of components to be worked with is provided: CPU, Thermal compound, CPU heat sink/fan assembly, RAM module (2), and Motherboard. Below the 3D view is a toolbar with icons for CPU, Thermal Compound, Heatsink, Motherboard Screws, Motherboard, and NIC. A red circle highlights the navigation arrows at the bottom right of the interface.

We Will Work Through LEARN

- Check **the box** to show instructions.
- Drag parts from the **antistatic mat** in left to right order.

The screenshot displays the Cisco IT Essentials Virtual Desktop interface. At the top left is the Cisco logo, and at the top right is a 'Help' icon. The main window title is 'IT Essentials Virtual Desktop'. On the left side, there is a navigation pane with a 'LEARN' tab highlighted in a green circle. Below it, the 'POWER SUPPLY' section is active, showing instructions for installation. A red circle highlights the 'Hide Instructions' button. Below the instructions are several menu items: 'MOTHERBOARD', 'ADAPTER CARDS', 'INTERNAL DRIVES', 'DRIVES IN EXTERNAL BAYS', 'INTERNAL CABLES', and 'EXTERNAL CABLES'. At the bottom of the navigation pane are 'TEST' and 'EXPLORE' buttons. The main workspace shows a 3D model of a computer case with a power supply unit being installed. A purple circle highlights the 'ANTISTATIC MAT' button in the bottom toolbar. The toolbar also contains icons for 'Power Supply', 'Power Supply Screws', 'RAM 1', 'RAM 2', 'CPU', 'Thermal Compound', and 'He'. On the left side of the 3D workspace, there are three circular icons: a refresh icon, a download icon, and a refresh icon.

Virtual Desktop Lab

- A worksheet accompanies the lab.
- Answer questions as you work through the lab.
- Type your answers, save and submit the worksheet.

AP Computer Science Principles
Virtual Desktop Assembly Lab Name _____

Instructions: This lab will teach you the basics of computer assembly using a simulated "virtual" PC. To start, use the Windows file explorer to navigate to This PC | Local Disk (C:) | en_ITEC_VA_Desktop_v40. Open the folder and right click on [index.html](#). Choose Open With | Microsoft Edge.

You should see a welcome screen similar to the picture below.



(OPTIONAL: You may find it easier to visit it one of the following links instead:
https://cisco.com/edu/You/Compilers/Classroom_ITEC_VA_Desktop_v40/Box/You/edu/Features/
https://www.cisco.com/edu/You/Compilers/Classroom_ITEC_VA_Desktop_v40/Box/You/edu/Features/)

Click on the right arrow at the bottom to take a quick tour of the Cisco IT essentials virtual desktop program. When you finish, you should see a picture similar to the one below.



get the message *How it works: you are ready to begin!* click on the power supply under *Learn* to start the simulation. Drag the parts from the *anastatic* mat to the computer case and move them into position. As you use Virtual Desktop to practice putting a computer together, answer the following questions.

1. What are the 7 categories ("layers") listed that are typically part of a computer build?

- i. _____ ii. _____
iii. _____ iv. _____
v. _____ vi. _____

vi. _____

2. Click on the Power Supply Layer. Install the power supply and screws. Now click on Motherboard. You should see a picture of the motherboard like this.



Why do you think you are asked to install the RAM and CPU on the motherboard before installing the motherboard in the case?

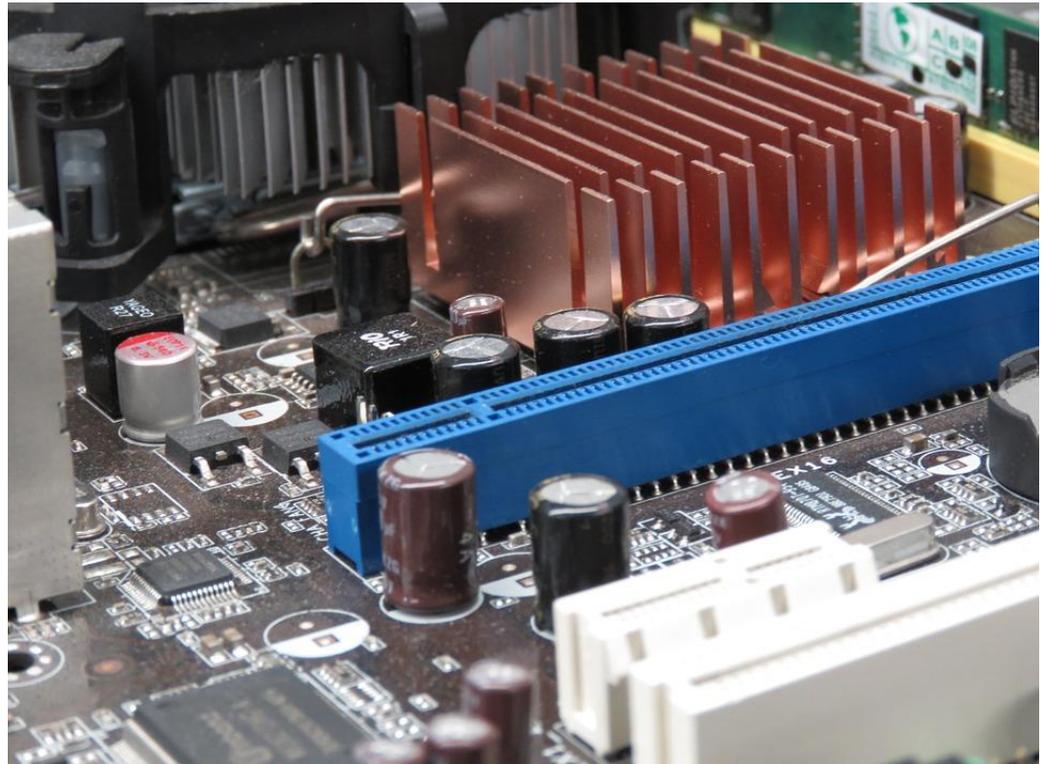
3. Install the RAM. Is it possible to install the RAM backwards? Why or why not?

4. Install the CPU. What is the significance of the triangle on one corner of the CPU? What do you think would happen if the CPU was crooked when the load plate is closed?

5. Install the Thermal Compound. What is the purpose of the thermal compound?

Capacitors Store Electrical Charge

- Unplug the computer and then press the power button to discharge the capacitors.



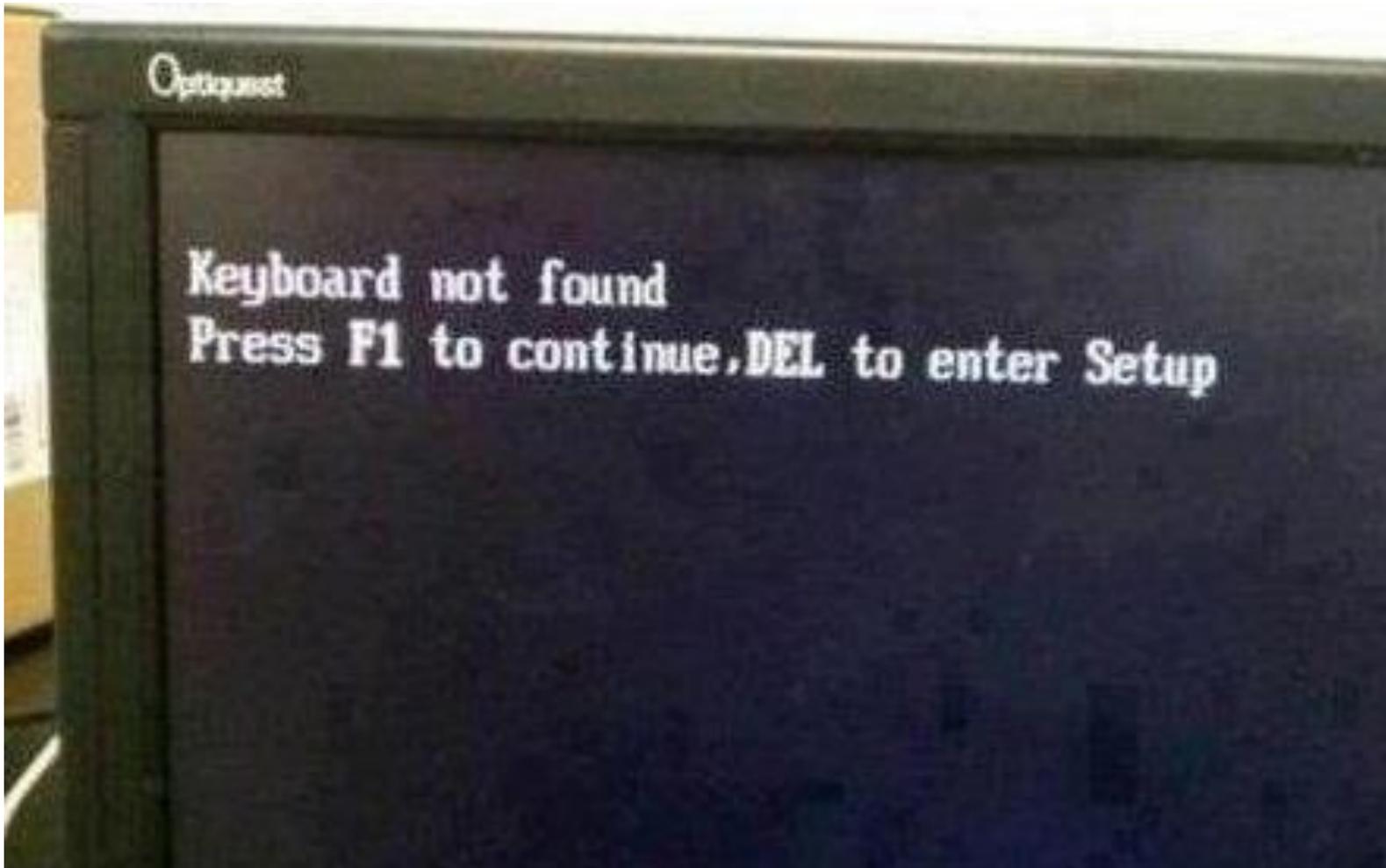
Computer Assembly Lab

- Find a partner or two.
- First, **test your computer** by attaching a monitor, keyboard and mouse.
- Then disassemble it and label the parts.
- Call me over to check.
- Reassemble the computer.
- **Test it again** by reattaching a monitor, keyboard and mouse.

Hooking Up the Computer

- You will test your computer to see if it **boots** (works) twice, once before you take it apart and then after you put it back together.
- To test the computer you'll need to connect the following cables to their matching ports:
 - Monitor
 - Keyboard
 - Power

A Funny Error Message if you Forget to Connect a Keyboard



Monitor: Video VGA Cable

- Nearly all of the monitors in room 334 use VGA cables to connect the monitor.
- VGA has a 3-row, 15-pin female trapezoidal connector.



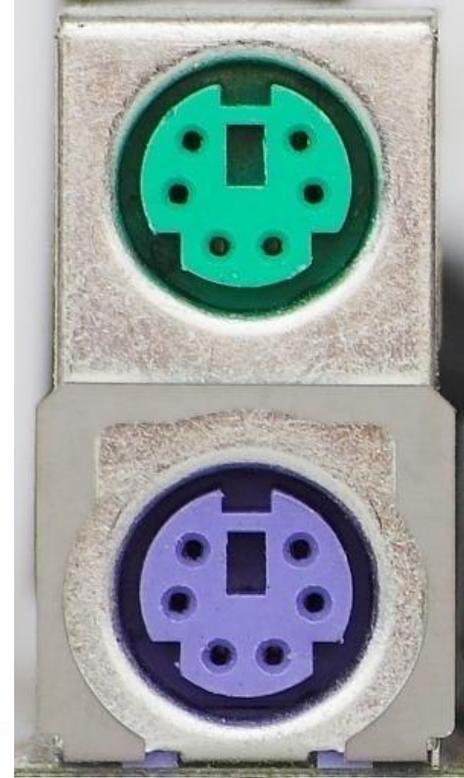
USB Keyboard & Mouse

- You'll see two types of keyboard and mouse ports in room 334.
- The easiest is USB. USB cables can be connected to any USB port whether the computer is on or off.



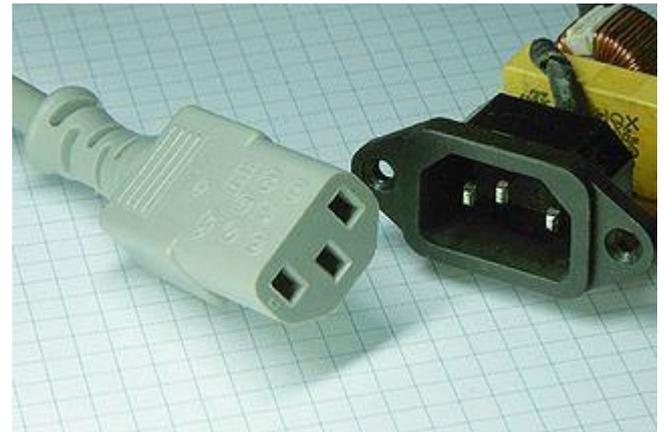
PS/2 Keyboard & Mouse

- Another (older) type of keyboard and mouse port is the PS/2. The PS/2 port is a 6-pin mini-DIN female connector. The connectors for the keyboard are usually blue and mouse green.
- ONLY CONNECT OR DISCONNECT PS/2 CONNECTIONS WHEN THE COMPUTER IS OFF.



Power

- Power should always be connected last. Virtually all desktop PCs use the *IEC C13* power cord.
- The cord plugs into the *IEC C14* socket on the power supply.



Boot to the OS

- When you turn on the computer it should load the operating system.
- This is called booting.
- If your computer boots the hardware is installed correctly.



The specific steps for disassembly will vary with each computer

- Remove the case
- Remove the hard drive and cables
- Remove the DVD drive and cables
- Remove the RAM
- Remove the heat sink and fan
- Remove the CPU
- Reassemble in reverse order

Open the Computer Case



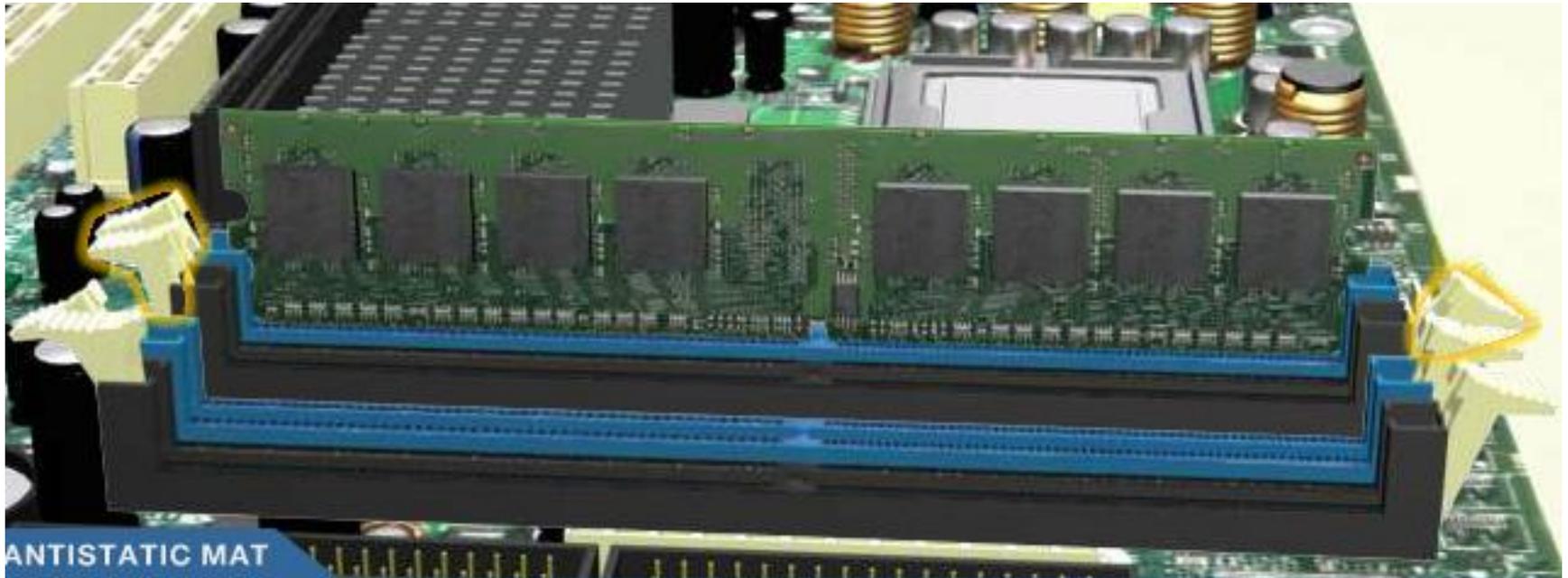
Remove the Hard Drive



Remove the DVD



Press the levers to remove the RAM



Remove the Heat Sink and Fan



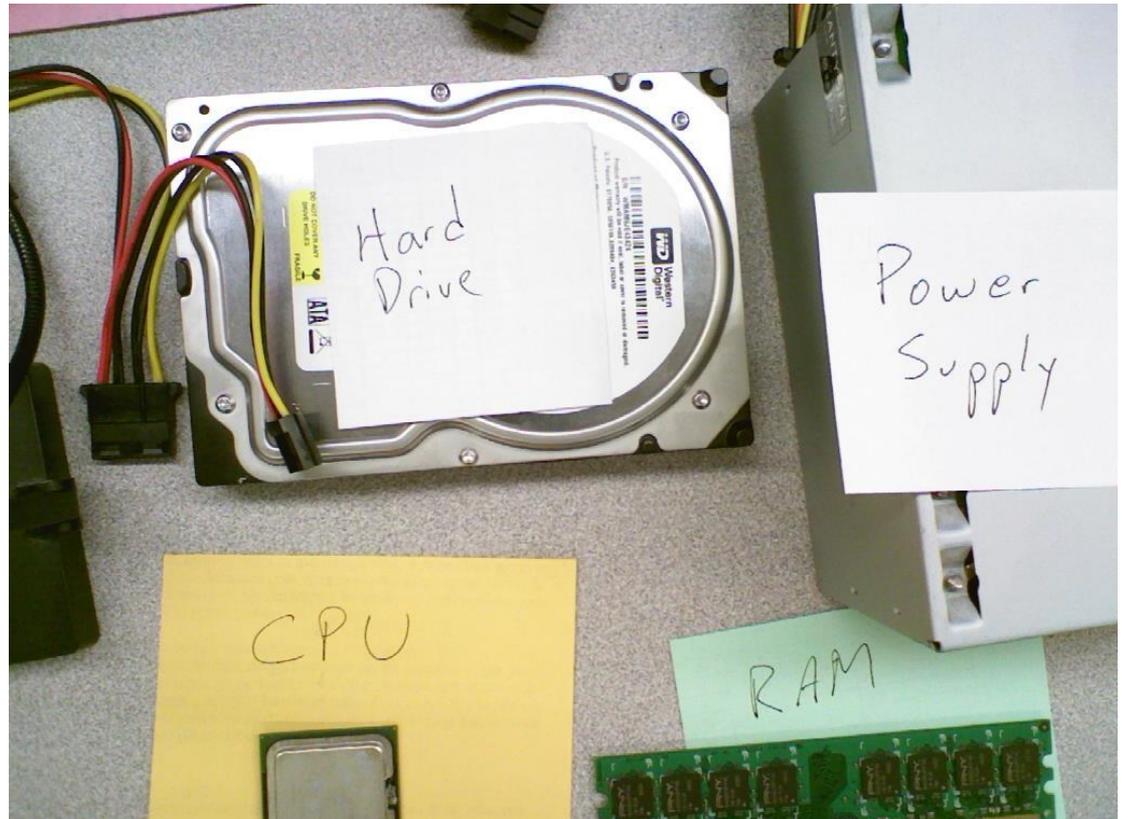
Remove the CPU

- Left the highlighted lever
- Open the plate and remove the CPU



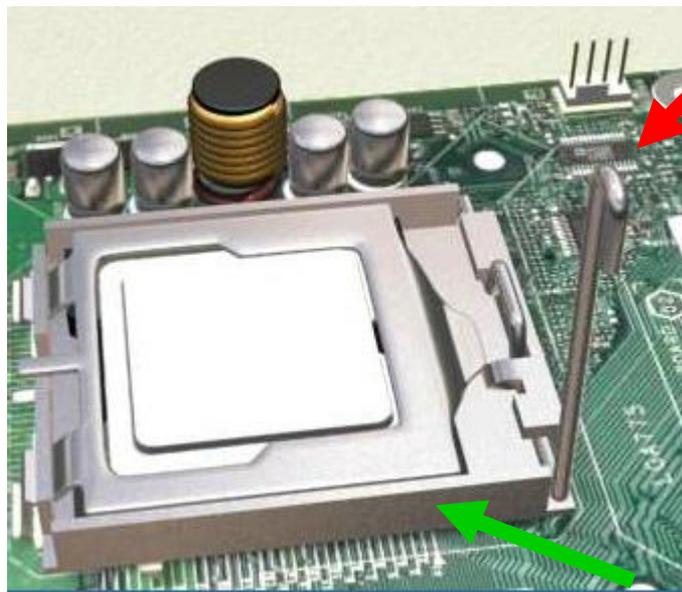
Label the following parts and show your teacher that you've taken it apart: Hard Drive, Optical Drive, Power Supply, RAM, Heat sink, and CPU.

Assemble the computer in reverse order.



Watch out for this assembly mistake!

- Watch out! The CPU is fastened to the motherboard with a lever that presses the CPU into its **socket**.
- If the CPU is crooked, pushing the **lever** will **break the pins** on the CPU and/or the socket.



Computer Assembly

- Finish the Virtual Desktop lab first.
- In groups of 2 or 3, disassemble the computer, label the parts, and then notify me that you are ready to assemble it.
- There is nothing to turn in.
- If you assemble the machine and it boots, you get full credit.

POST: Power On Self Test

- When you turn the computer on it tests the hardware components.
- If something is wrong, you'll hear a series of beeps. Otherwise, you should see a BIOS screen like this one.



Boot to the OS

- If the computer “POSTs” it will then try to load the operating system.
- This is called **booting**.
- If you get this far the assembly was successful.



Beep Codes

[PC magazine](#) lists some common beep codes:

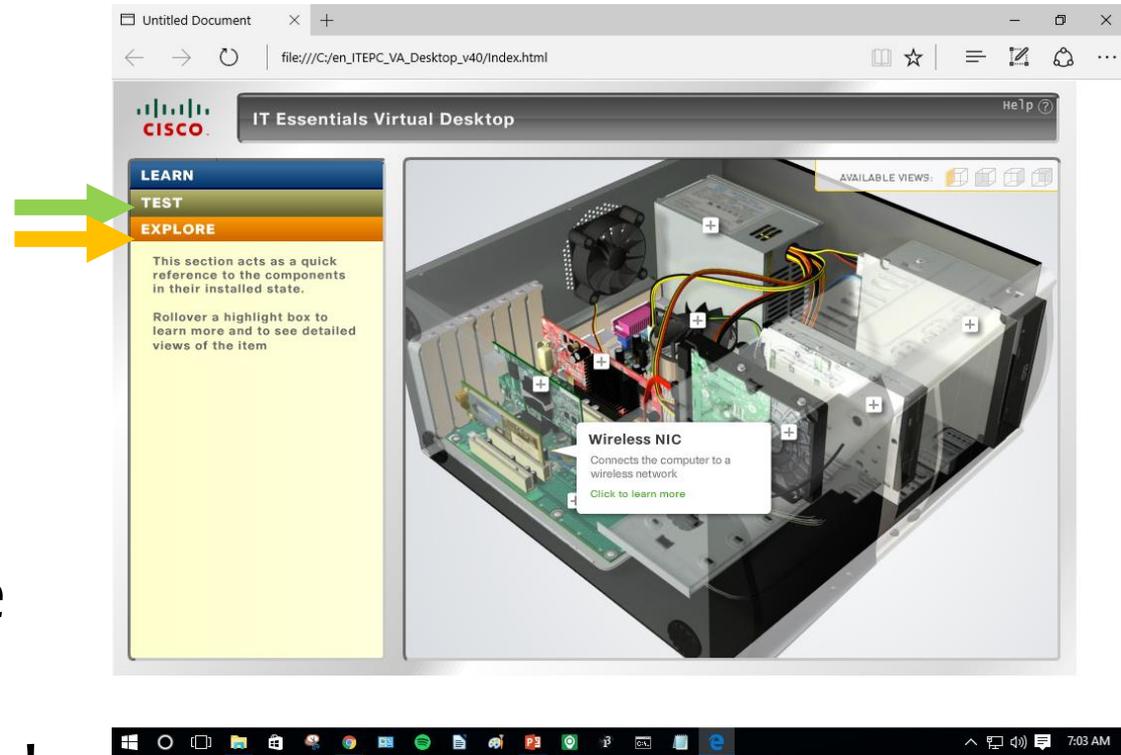
- 1 Beep - Refresh Failure, Reseat/replace memory, troubleshoot motherboard.
- 2 Beeps - Parity Error, Reseat/replace memory, troubleshoot motherboard.
- 3 Beeps - Memory Error (first 64KB), Reseat/replace memory.
- 4 Beeps - Timer Failure, Troubleshoot motherboard.
- 5 Beeps - Processor Failure, Troubleshoot CPU, motherboard.
- 6 Beeps - Keyboard Controller Failure, Troubleshoot keyboard, motherboard.
- 7 Beeps - Virtual Mode Exception Error, Troubleshoot CPU, motherboard.
- 8 Beeps - Display Memory Failure, Troubleshoot graphics card, motherboard.
- 9 Beeps - ROM BIOS Checksum Failure, troubleshoot motherboard.
- 10 Beeps - CMOS Shutdown Register Failure, Troubleshoot motherboard.

No Beep Code?

- If you put a computer together, and there is power (the fan spins), but it won't post and the display is black, check the CPU.
- Those symptoms could mean a missing or improperly seated processor.

Extra Time?

- If you are finished with both the Computer Tower disassembly and the PCPartsPicker activity, consider working through the **test** and **explore** sections of the Virtual PC.



Choosing Components for a Computer Build

- Building your own computer from parts lets you customize it exactly the way you want
- Plus, it's fun!

The Case

- Start by choosing a case.
- There is a large variety of cases.
- Once you've chosen the case you can match its form factor to the form factor of the motherboard and power supply.



The Motherboard



- Next, choose a motherboard that fits your case by matching the case's form factor.
- You'll also want to think about features like the processor, SATA ports, slots for RAM, USB, Firewire, expansion slots, integrated video, etc.

The CPU and RAM

- The CPU can be thought of as the “brain” of the computer.
- Needs to match the *Socket Type* on the motherboard.
- The RAM will also need to be compatible with the motherboard (8 Gb is a good amount).

Drives: Non-volatile Storage

- Your computer will need some form of non-volatile storage.
- You should choose a hard drive (HHD) and/or a solid state drive (SSD).
- Optional: flash memory, optical drives and/or floppy drives.



Optional Expansion Cards

- Video Card
- TV Tuner
- Extra USB ports



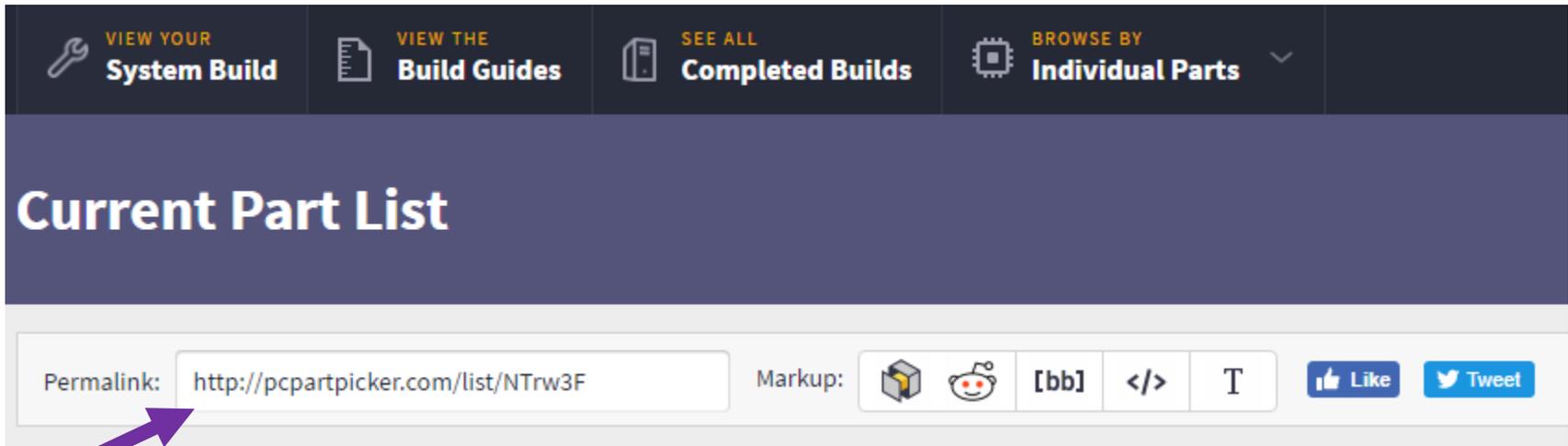
The Power Supply

- The Power Supply is the last thing to choose.
- It should match the form factor of the case.
- You'll need a power supply that provides more than the total wattage required from all the computer components.



PCPartPicker

- Makes it easy as it won't allow you to choose parts that don't match
- Submit the **permalink** to your finished build



VIEW YOUR System Build

VIEW THE Build Guides

SEE ALL Completed Builds

BROWSE BY Individual Parts

Current Part List

Permalink:

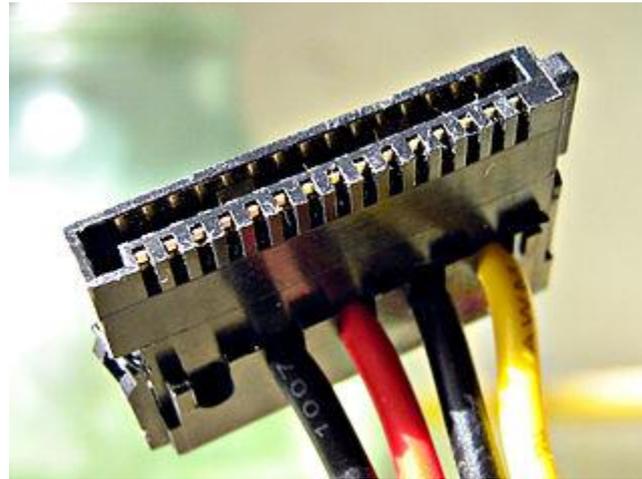
Markup:   [bb] </> T

 Like  Tweet

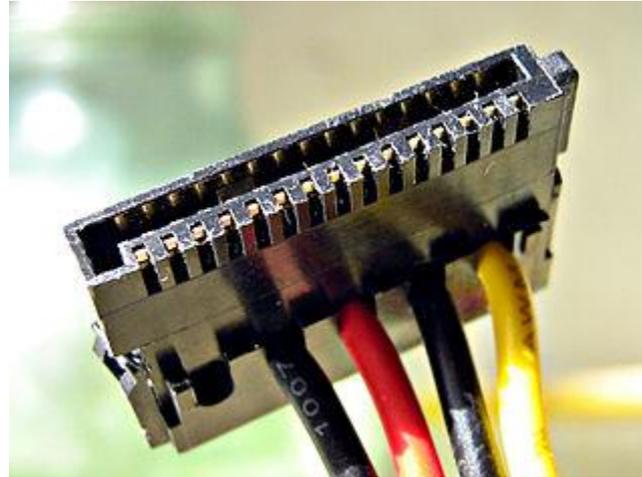
Let's Play

Know your computer parts!

What's this?

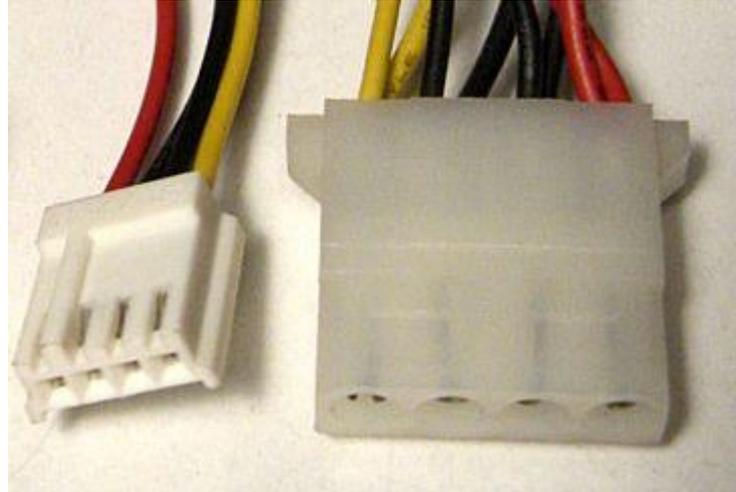


What's this?

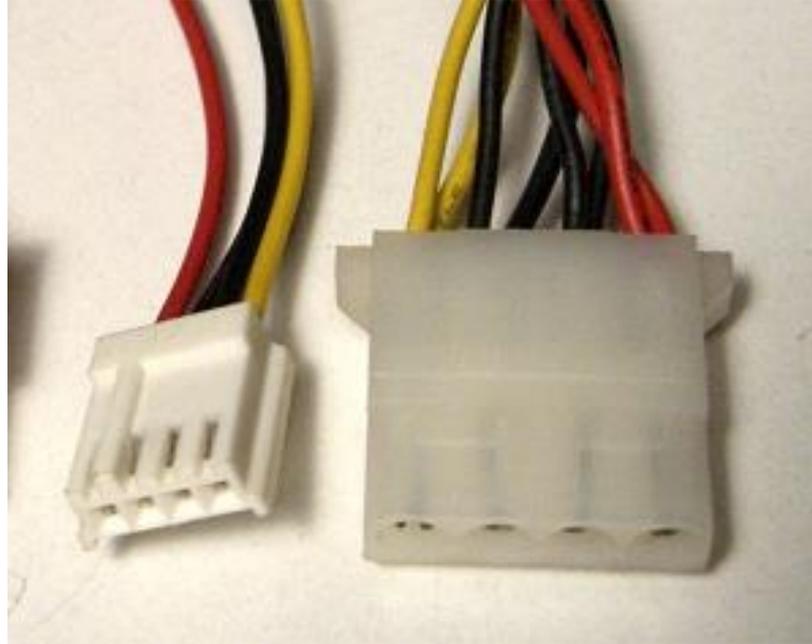


- 15 pin SATA power cable used for hard drives

What are these?



What are these?



- Older style power connectors, Berg (floppy) on the left and Molex (hard drive and DVD) on right.

What's this?



What's this?



- VGA cable for connecting a monitor to the computer.

What is this?



What is this?



- Older style data cables for PATA hard drives and DVD drives .

What's this?

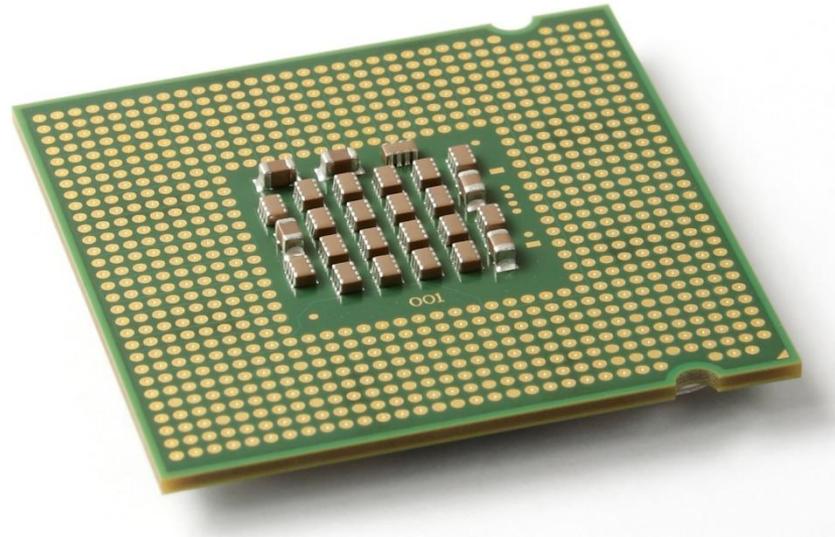


What's this?



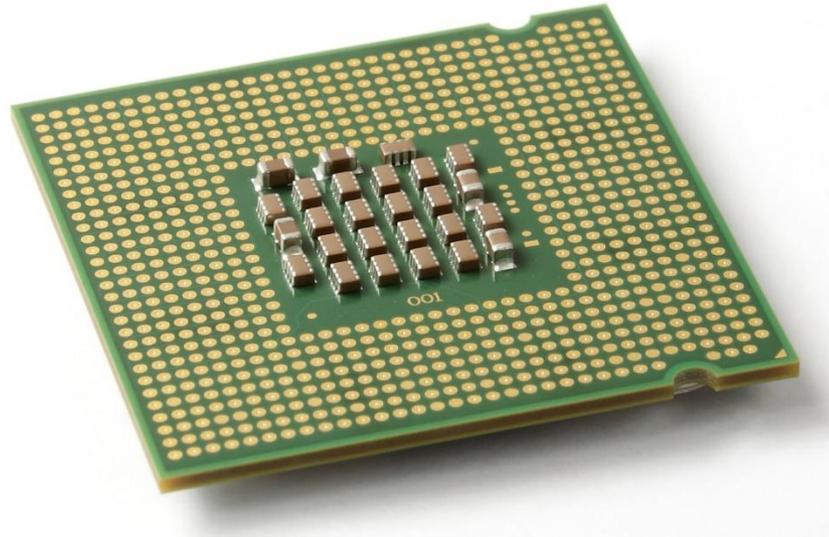
- USB cable, both power and data for printers keyboards, mice and other devices

What's this?



[Image](#): By [Lamprosleferis](#). This file is licensed under the [Creative Commons Attribution-Share Alike 4.0 International](#) license.

What's this?



- CPU or Central Processing Unit, the “brain” of the computer that performs the basic operations of the computer.

What's this?



What's this?



- Power Supply, provides power to all the computer components.

What's this?

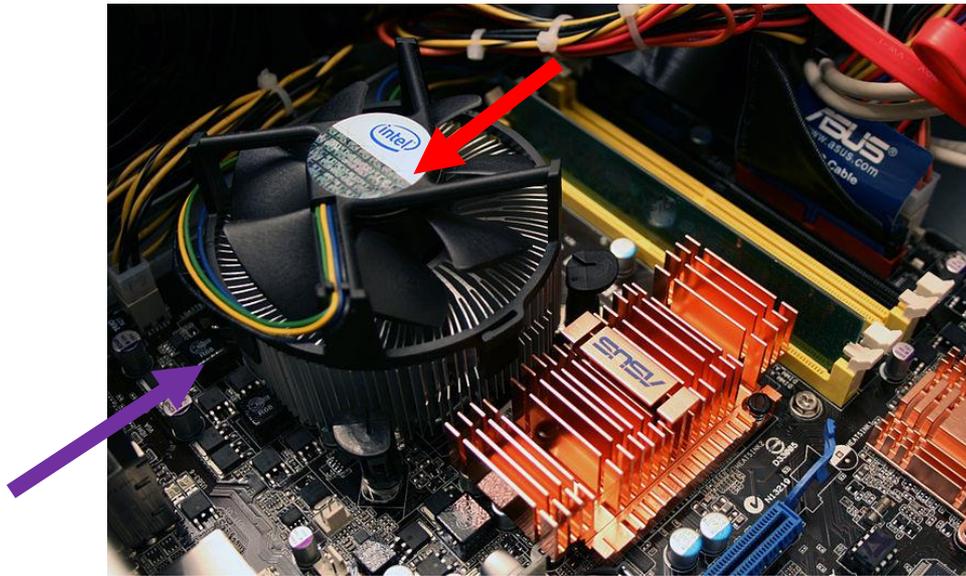


What's this?

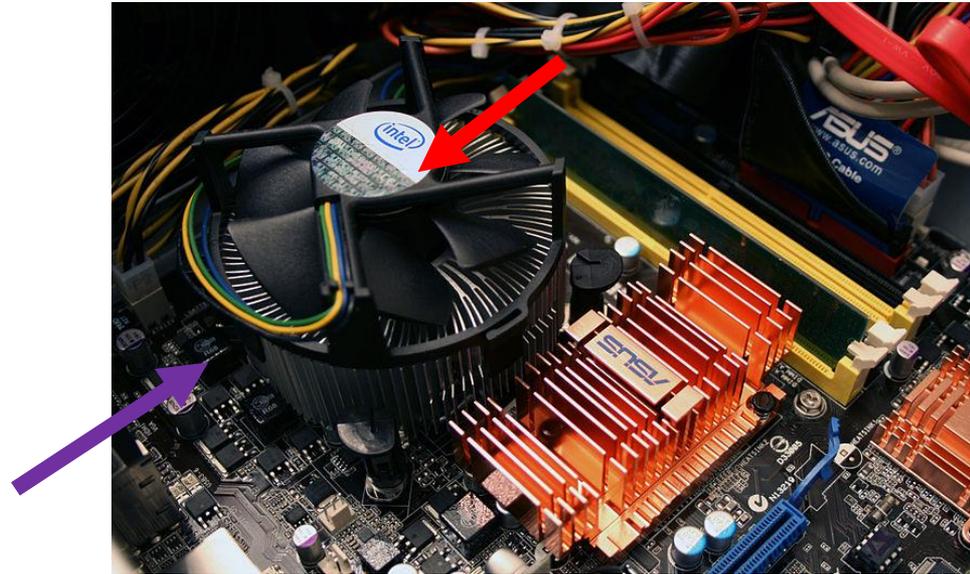


- SATA 7 pin data cable for newer hard drives

What's are these?

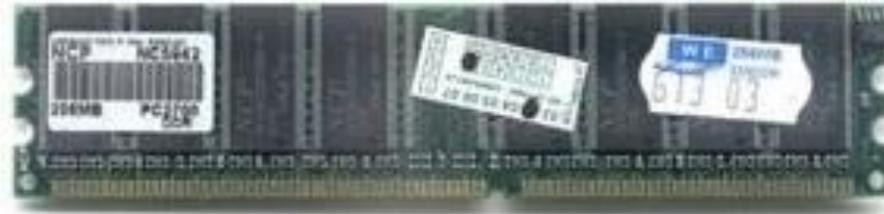


What's are these?

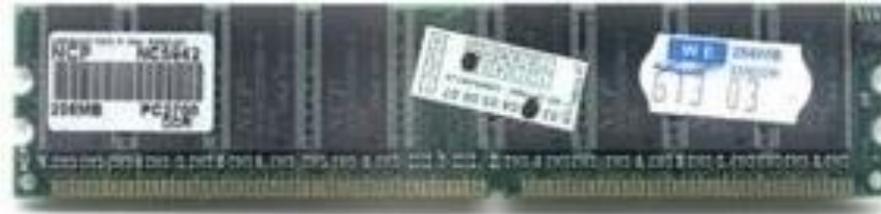


- Heatsink and fan to cool the cpu.

What's this?

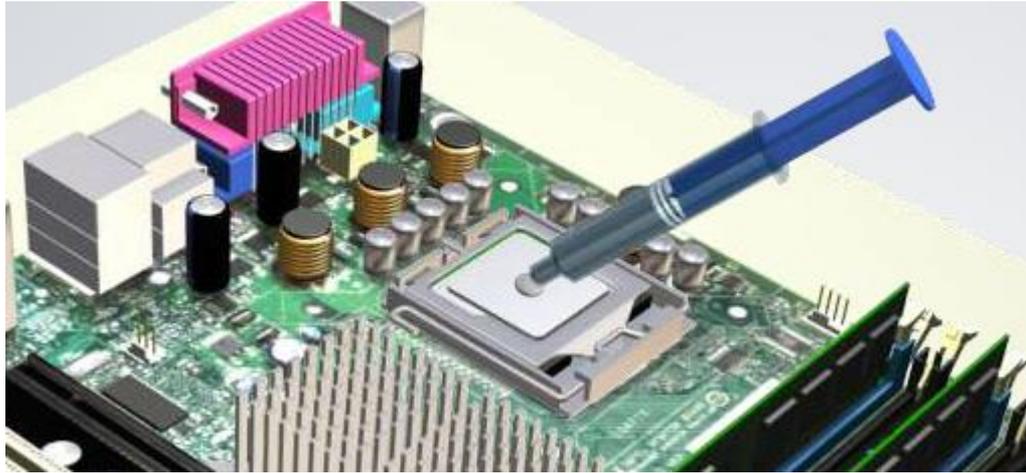


What's this?

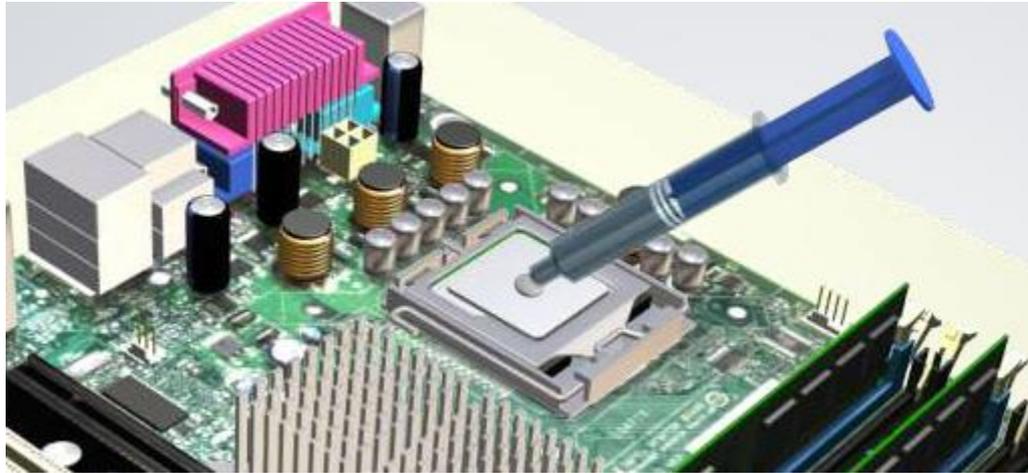


- RAM, or random access memory. Stores the operating system and any running programs. Volatile, so loses contents without power.

What's the stuff in the tube?



What's the stuff in the tube?



- Thermal grease. Used to fill microscopic air gaps between CPU and heatsink.

Computer Parts on the Next Quiz

- You will be expected to identify the parts you labeled for the Tower Assembly lab:
- CPU
- Heat sink
- RAM
- Hard drive
- DVD drive
- Power Supply

Cleaning a Computer

- For the interior of a computer I've used a vacuum to get rid of heavy dust build up, it's not really recommended.
- Compressed air is better, but much more expensive.
- For exterior components like the case, monitor, mouse and keyboard a damp cloth is really all you need

Numeral Systems

- The common system of numerals is **base 10** called decimal.
- You can have other systems with a different **base** (also called **radix**).
- In computers, the two most common systems are:
 - Base 2 called **binary**
 - Base 16 called **hexidecimal**

Place Value and Expanded Notation

- In Elementary school, students are asked to write numbers in expanded notation.
- $1,235 = 1000 + 200 + 30 + 5$
- $= 1 * (10^3) + 2 * (10^2) + 3 * (10^1) + 5 * (10^0)$
- In a ***decimal*** number each digit has a place value that is a ***power of 10***.

Binary Place Values are Powers of 2

- In **Binary**, each digit has a place value that is a **power of 2**.
- Each digit of a binary number is called a **bit**.
- This binary number is **4 bits**
 - 1011

Converting Binary to Decimal

- To convert binary to decimal, just write the number out in expanded notation.
- $1011 = 1 * (2^3) + 0 * (2^2) + 1 * (2^1) + 1 * (2^0)$

Converting Binary to Decimal

- To convert binary to decimal, just write the number out in expanded notation
- $1011 = 1 * (2^3) + 0 * (2^2) + 1 * (2^1) + 1 * (2^0)$
- $= 1*8 + 0*4 + 1*2 + 1*1$

Converting Binary to Decimal

- To convert binary to decimal, just write the number out in expanded notation
- $1011 = 1 * (2^3) + 0 * (2^2) + 1 * (2^1) + 1 * (2^0)$
- $= 1*8 + 0*4 + 1*2 + 1*1$
- $= 8 + 0 + 2 + 1$

Converting Binary to Decimal

- So 1011 in binary is 11 in decimal

- $1011 = 1 * (2^3) + 0 * (2^2) + 1 * (2^1) + 1 * (2^0)$

- $= 1 * 8 + 0 * 4 + 1 * 2 + 1 * 1$

- $= 8 + 0 + 2 + 1$

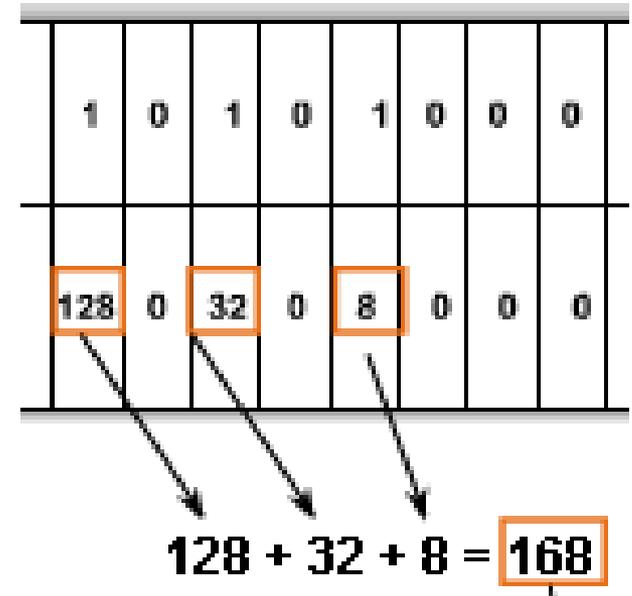
- $= 11$

The First 8 Powers of 2

- $2^0 = 1$
- $2^1 = 2$
- $2^2 = 4$
- $2^3 = 8$
- $2^4 = 16$
- $2^5 = 32$
- $2^6 = 64$
- $2^7 = 128$

Binary Numbers Often Come in Groups of Eight Bits that are Called Bytes

- If all 8 bits are 0s **00000000** then the value of the byte is 0.
- If all 8 bits are 1s, **11111111** then the value of the byte is 255 (128+64+32+16+8+4+2+1).
- If the 8 bits are mixed, such as **10101000**, add the place values of the 1 bits: $128 + 32 + 8 = 168$.



You can also “subtract the zeros” from 255.

- If all 8 bits are 1s, **11111111** then the value of the byte is 255 ($128+64+32+16+8+4+2+1$).
- If the 8 bits are mostly ones, such as **1111011**, subtract the place values of the 0 bits from 255.

You can also “subtract the zeros” from 255.

- If all 8 bits are 1s, **11111111** then the value of the octet is 255 (128+64+32+16+8+4+2+1).
- If the 8 bits are mostly ones, such as **1111011**, subtract the place values of the 0 bits from 255
- =255 - ?

You can also “subtract the zeros” from 255.

- If all 8 bits are 1s, **11111111** then the value of the octet is 255 (128+64+32+16+8+4+2+1).
- If the 8 bits are mostly ones, such as **1111011**, subtract the place values of the 0 bits from 255
- $=255 - 4 = ?$

You can also “subtract the zeros” from 255.

- If all 8 bits are 1s, **11111111** then the value of the octet is 255 (128+64+32+16+8+4+2+1).
- If the 8 bits are mostly ones, such as **1111011**, subtract the place values of the 0 bits from 255.
- $=255 - 4 = 251$

Binary Game!

The image shows a screenshot of a game interface. On the left, a large dark brown panel displays a binary number '1010110' in a glowing orange font. Above and below this panel are two rows of eight boxes, each containing a power of two: 128, 64, 32, 16, 8, 4, 2, and 1. Below the binary number, a row of eight colored boxes (seven pink, one yellow) represents the binary digits. An equals sign follows, and a small grey box contains the decimal value '34'. On the right, a vertical sidebar contains the title 'BINARY' in a glowing cyan font. Below the title, three rows of text show 'Score 0', 'Level 1', and 'Lines Left 15'. At the bottom of the sidebar are two buttons: '|| Pause game' and 'X End Game'.

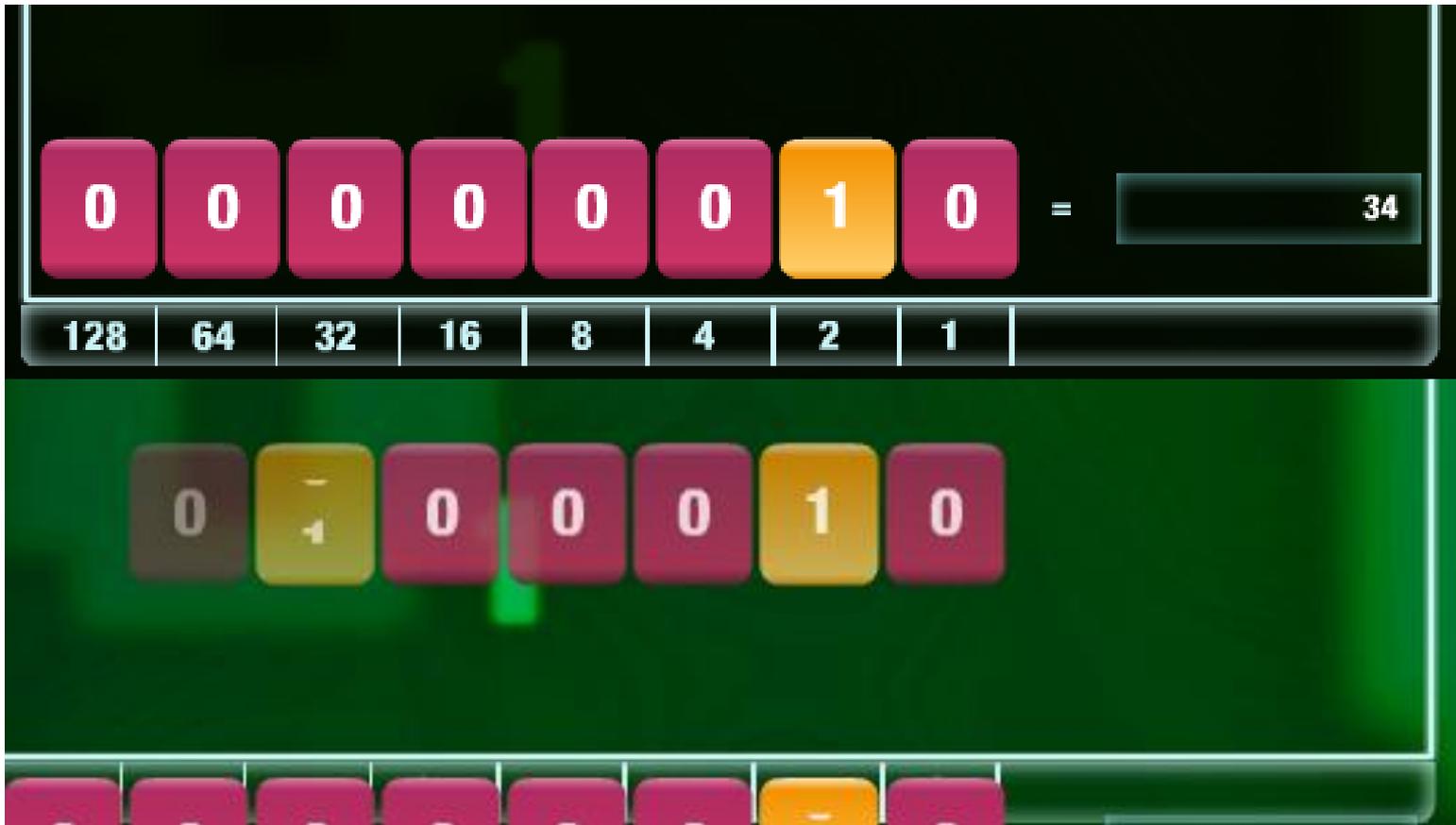
<http://www.wordfreegames.com/game/binary-game.html>

There are Two Kinds of Problems



- The first kind of problem is to convert from base 10 to binary.
- Here we are asked to make 34 in binary.
- The problem is:
 - $?*(2^7)+?(2^6)+?(2^5)+?(2^4)+?(2^3)+?(2^2)+?(2^1)+?(2^0)=34$
- Clicking on the button above the power of two "flips" to either 1 or 0.

There are Two Kinds of Problems



When I click on the button above 32, I get the problem right and the level disappears.

There are Two Kinds of Problems



- The other kind of problem is to convert from binary to base 10;
- The problem is
 - $0*(2^7)+0*(2^6)+0*(2^5)+0*(2^4)+0*(2^3)+0*(2^2)+1*(2^1)+0*(2^0)=$
?
- Clicking in the box next to the equals sign lets me type or click on the number pad to enter the answer in base 10.

There are Two Kinds of Problems



A digital interface for binary to decimal conversion. It features a row of eight pink buttons labeled 0, 0, 0, 0, 0, 0, 1, 0 from left to right. A green '1' is positioned above the seventh button. Below the buttons is a row of eight boxes containing the values 128, 64, 32, 16, 8, 4, 2, and 1. An equals sign is followed by an empty rectangular input field.



A digital interface for binary to decimal conversion, similar to the one above but with a calculator overlay. The buttons and weights are the same. A blue '1' is positioned above the seventh button. The calculator overlay on the right includes a numeric keypad (7-9, 4-6, 1-3, DEL, 0, ←) and a display showing the number 2. The equals sign is followed by a rectangular input field containing the number 2.

In Class Activity

- Play the [binary game](#) until you can complete level three.
- <http://www.wordfreegames.com/game/binary-game.html>
- <https://learningnetwork.cisco.com/docs/DOC-1803>

Bytes and File Sizes



- The 8 bit **byte** is the fundamental unit of computer storage.
- You may have heard words like *megabyte*, *kilobyte*, *gigabyte*, etc.
- Those words are all different amounts of bytes.
- We're going to learn more about them today.

Each byte unit is roughly 1000 times as big as the next smallest byte unit.

- bit: one binary digit
- byte: eight binary digits
- Kilobyte (KB): 1,000 (approx.) bytes
- Megabyte (MB): 1,000,000 (approx.) bytes
- Gigabyte (GB): 1,000,000,000 (approx.) bytes
- Terabyte (TB): 1,000,000,000,000 (approx.) bytes
- Petabyte (PB): 1,000,000,000,000,000 (approx.) bytes
- Exabyte (EB): 1,000,000,000,000,000,000 (approx.) bytes

Every bit doubles the number of possible values.

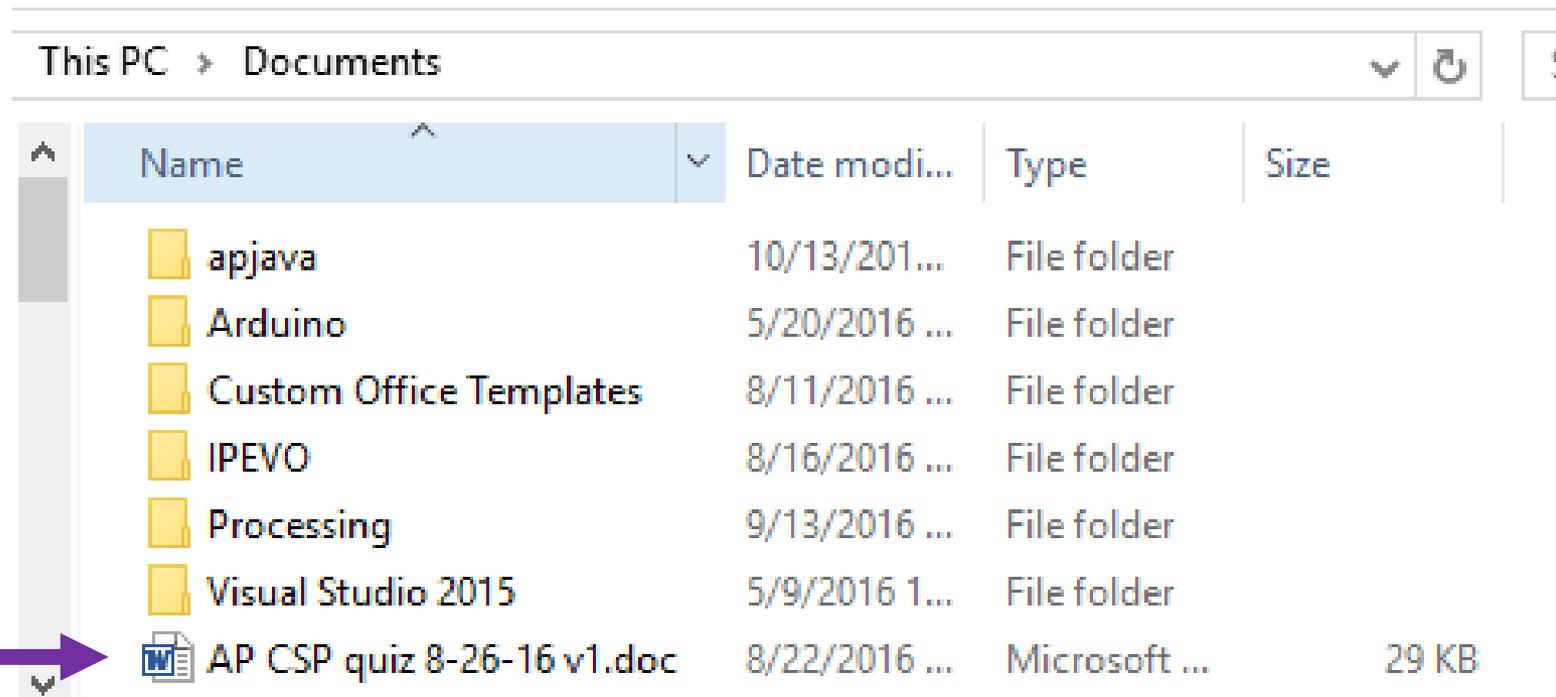
- One bit: two values **0,1**
- Two bits: four values **00,01,10,11**
- Three bits: eight values
000,001,010,011,100,101,110,111
- And so on. . .

1000 is an Approximation of 1024

- While 1 kilobyte (KB) is *approximately* 1000 bytes it is *exactly* 1024 bytes.
- So a megabyte is *exactly* 1024 kilobytes or $(1024)^2$ bytes.
- Computer marketers and most other people seem to prefer to approximate computer storage in groups of 1000.
- For purposes of APCS Principles the distinction is not important - “about a million bytes” is a fine, close-enough interpretation for megabyte.

Bytes and File Sizes

- **This quiz** is 29KB or roughly 29000 bytes.

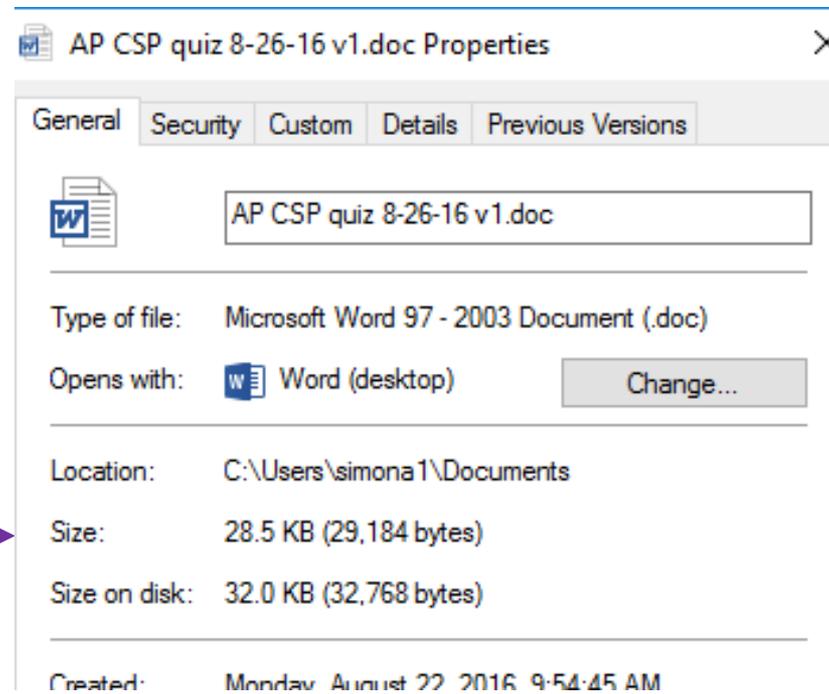


This PC > Documents

Name	Date modified	Type	Size
apjava	10/13/201...	File folder	
Arduino	5/20/2016 ...	File folder	
Custom Office Templates	8/11/2016 ...	File folder	
IPEVO	8/16/2016 ...	File folder	
Processing	9/13/2016 ...	File folder	
Visual Studio 2015	5/9/2016 1...	File folder	
AP CSP quiz 8-26-16 v1.doc	8/22/2016 ...	Microsoft ...	29 KB

Bytes and File Sizes

Another way to find **the size** of a file is to *right click* and choose *properties*.



Bytes and File Sizes

- Download and complete the worksheet.
- Save your finished worksheet and submit.

Activity Guide - Bytes and File Sizes



What is a byte? A byte is a unit of data that is 8 bits long. A byte is the standard “chunk size” for binary information in most modern computers

Larger Chunks of Data: On modern computers the amount of information we can create and store has grown so large that we need new units of measurement to describe the size of our data. Use these websites for your research.

- **Stanford University - CS 101 - Kilobytes Megabytes Gigabytes:** <https://web.stanford.edu/class/cs101/bits-gigabytes.html>
- **Computer Hope - How much is 1 byte, kilobyte, megabyte, gigabyte, etc.?** <http://www.computerhope.com/issues/chspace.htm>

Unit	Number of Bytes (approx)	Example of File Type or Data Measured in this Unit
Kilobyte (KB)		
Megabyte (MB)		

Hexadecimal Numbers

- The other common numeral system in computing (besides binary) is Hexadecimal (or *hex* for short).
- Hexadecimal is base 16.
- It uses sixteen distinct symbols, the symbols **0–9** to represent values zero to nine, and **A, B, C, D, E, F** to represent values ten to fifteen.

Computer Settings are Often inH

```
Ethernet adapter Ethernet:  
  
Connection-specific DNS Suffix . . . :  
Link-local IPv6 Address . . . . . : fe80::1986:7f3e:7b6f:d81e%2  
IPv4 Address. . . . . : 10.66.3.81  
Subnet Mask . . . . . : 255.255.240.0  
Default Gateway . . . . . : 10.66.1.1  
  
Tunnel adapter isatap.{071A18E8-D461-477B-A84C-3E1450324AC8}:
```

- **fe80::1986:7f3e:7b6f:d81e%2**
- **071A18E8-D461-477B-A84C-3E1450324AC8**
- You can usually spot hex because it has only the digits and the letters **A-F**.

Converting Hex to Decimal

- In a hex number, each place value is a power of 16.
- **13FA =**

Converting Hex to Decimal

- In a hex number, each place value is a power of 16.
- $13FA = 1 * (16^3) + 3 * (16^2) + 15 * (16^1) + 10 * (16^0)$

Converting Hex to Decimal

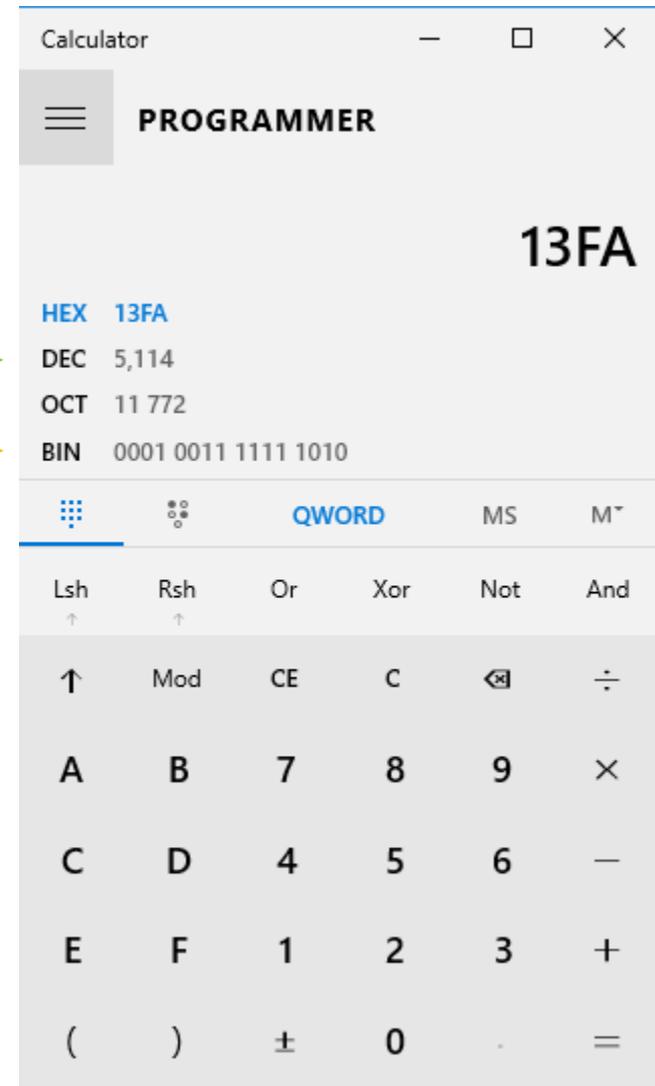
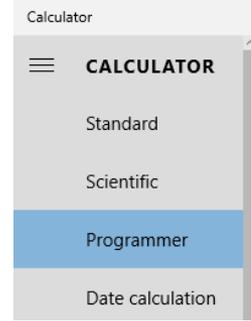
- In a hex number, each place value is a power of 16
- $13FA = 1 * (16^3) + 3 * (16^2) + 15 * (16^1) + 10 * (16^0)$
- $= 4096 + 768 + 240 + 10$

Converting Hex to Decimal

- In a hex number, each place value is a power of 16
- $13FA = 1 * (16^3) + 3 * (16^2) + 15 * (16^1) + 10 * (16^0)$
- $= 4096 + 768 + 240 + 10$
- $= 5114$

Converting Hex to Decimal Using Programmer Mode

- The Windows calculator has a **programmer mode** to convert from decimal to binary and hex.
- This shows **13FA** is 5,114 in **decimal** and 00100111111010 in **binary**.



If you use a table, converting back and forth from hex to binary is easy.

- To convert hexadecimal **F8** to binary, write down the binary for **F** first, then the binary for **8**.
- **F 8**
- **1111 1000**
- So, the answer is **11111000**
- That's all there is to it!

HEX	BINARY
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
A	1010
B	1011
C	1100
D	1101
E	1110
F	1111

Converting Binary to Hex

- Converting Binary to Hex is just as easy
 - 01011110101101010010
 - = 0101 1110 1011 0101 0010
 - = 5 E B 5 2
 - = 5EB52

HEX	BINARY
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
A	1010
B	1011
C	1100
D	1101
E	1110
F	1111

Magic Numbers

- Wikipedia has a [page on Magic Numbers](#)
- Distinctive Hexadecimal numbers that are used as markers in digital data
- **CAFEBABE**
- **DEADBEEF**
- **FACEFEED**
- **BAADF00D**
- **D15EA5ED**
- **DECEA5ED**
- **DEADC0DE**

Making Your Own Table

If you can count from 0 to 15 in hex and binary, you can easily make your own conversion table.

Hex	Binary
0	?
?	?
?	?
?	?
?	?
?	?
?	?
?	?
?	?
?	?
?	?
?	?
?	?
?	?
?	?
?	?
?	?

Making Your Own Table

If you can count from 0 to 15 in hex and binary, you can easily make your own conversion table.

Hex	Binary
0	?
1	?
2	?
3	?
4	?
5	?
6	?
7	?
8	?
9	?
?	?
?	?
?	?
?	?
?	?
?	?

Making Your Own Table

If you can count from 0 to 15 in hex and binary, you can easily make your own conversion table.

Hex	Binary
0	?
1	?
2	?
3	?
4	?
5	?
6	?
7	?
8	?
9	?
A	?
B	?
C	?
D	?
E	?
F	?

Making Your Own Table

If you can count from 0 to 15 in hex and binary, you can easily make your own conversion table.

Hex	Binary
0	0000
1	?
2	?
3	?
4	?
5	?
6	?
7	?
8	?
9	?
A	?
B	?
C	?
D	?
E	?
F	?

Making Your Own Table

If you can count from 0 to 15 in hex and binary, you can easily make your own conversion table.

Hex	Binary
0	0000
1	0001
2	?
3	?
4	?
5	?
6	?
7	?
8	?
9	?
A	?
B	?
C	?
D	?
E	?
F	?

Making Your Own Table

If you can count from 0 to 15 in hex and binary, you can easily make your own conversion table.

Hex	Binary
0	0000
1	0001
2	0010
3	?
4	?
5	?
6	?
7	?
8	?
9	?
A	?
B	?
C	?
D	?
E	?
F	?

Making Your Own Table

Notice that the binary numbers are in the same as they would be if they were decimal.

Hex	Binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
A	1010
B	1011
C	1100
D	1101
E	1110
F	1111

In Class

Unit 2 Lesson 4

Name(s) _____ Period _____ Date _____

Activity Guide - Encoding Hexadecimal Numbers



Hexadecimal: a number system comprised of the familiar ten arabic numerals (0, 1, 2 ... 9) as well as the first six English letters (A, B, C, D, E, F). Also referred to as a "base 16" number system, hexadecimal is used in the world of computing to help humans read and talk about large binary numbers. Since there are no symbols reserved for the numbers 10 through 15 in our familiar base 10 number system, the characters A through F are used to represent them.

Here are the first 16 numbers, in both binary and hexadecimal:

Number	Binary	Hex
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

A Scene from The Martian

CHANNELS ▾ @ 🔍

TIMESVIDEO LOG IN



OSCARS 2016

Anatomy of a Scene | 'The Martian'

By MEKADO MURPHY | Oct. 1, 2015 | 4:00

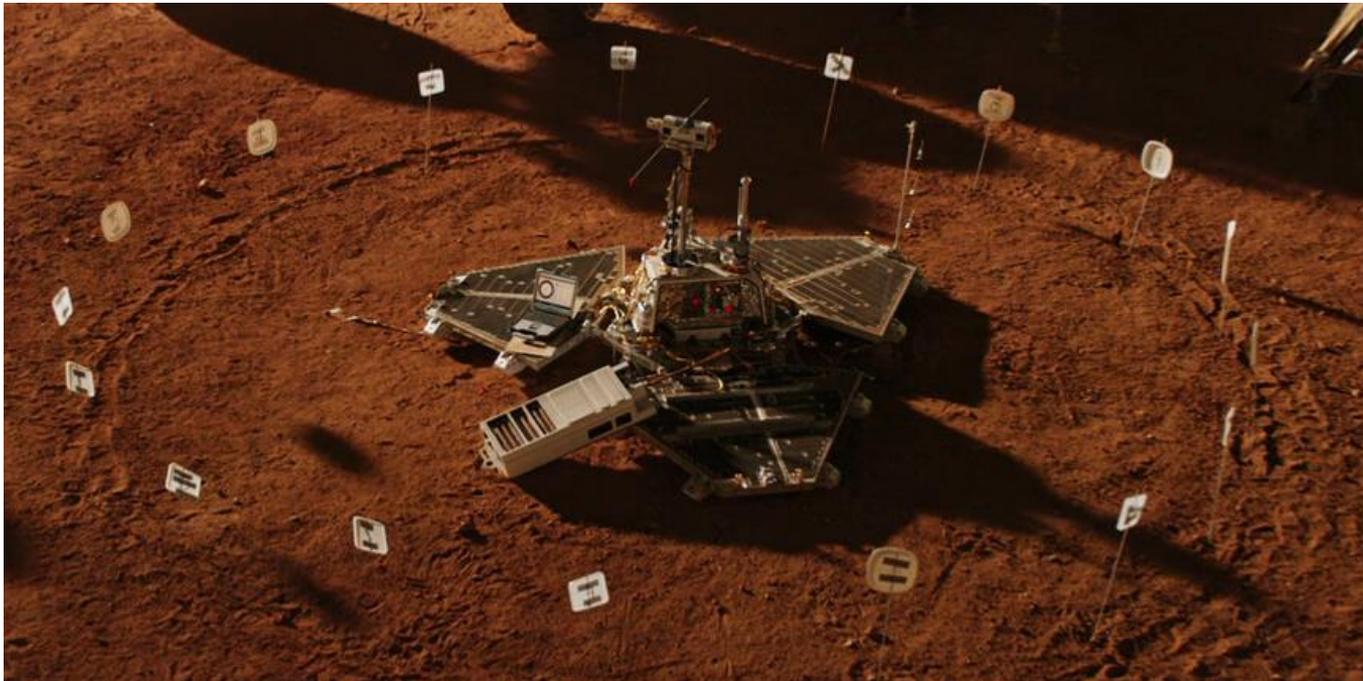
Ridley Scott narrates a sequence from "The Martian" featuring Matt Damon.

Related: [Article: 'The Martian' \(With Movie Trailer\): Ridley Scott Narrates a Scene](#) [Article: Review: In 'The Martian,' Marooned but Not Alone](#)

Share:      

Hexadecimal and ASCII in the Martian

- Having successfully used Pathfinder to contact earth, Matt Damon's character realizes he needs a better system than just Yes or No.
- Starting at 49' 20" he discusses the Hexadecimal and ASCII systems.



ASCII code

- Ultimately, everything in a computer is stored as a binary number
- ASCII code uses a 7 bit system to map letters of the alphabet to hex
- ASCII stands for *American Standard Code for Information Interchange*
- For example, the letter **A** maps to **41** in hex
- The letter **a** maps to **61** in hex

ASCII to Hex Table

ASCII	Hex	ASCII	HEX	ASCII	Hex
0	30	L	4C	g	67
1	31	M	4D	h	68
2	32	N	4E	I	69
3	33	O	4F	j	6A
4	34	P	50	k	6B
5	35	Q	51	l	6C
6	36	R	52	m	6D
7	37	S	53	n	6E
8	38	T	54	o	6F
9	39	U	55	p	70
A	41	V	56	q	71
B	42	W	57	r	72
C	43	X	58	s	73
D	44	Y	59	t	74
E	45	Z	5A	u	75
F	46	a	61	v	76
G	47	b	62	w	77
H	48	c	63	x	78
I	49	d	64	y	79
J	4A	e	65	z	7A
K	4B	f	66		

In Class

- Decode the following Hexadecimal/ASCII messages from the movie
 - 48 4F 57 41 4C 49 56 45
 - 43 52 4F 50 53 3F
 - 42 52 49 4E 47 53 4A 52 4E 52 4F 55 54
- Check your answers and read about hexadecimal in ***The Martian*** at <http://www.businessinsider.com/the-martian-hexidecimal-language-2015-9>

Practice Quiz Question:

- Consider the following numbers:
 - Binary 00010011
 - Decimal 18
 - Hexadecimal 11
- Which of the following lists the numbers in order from least to greatest?
 - Hexadecimal 11, Decimal 18, Binary 00010011
 - Binary 00010011, Hexadecimal 11, Decimal 18
 - Decimal 18, Hexadecimal 11, Binary 00010011
 - Binary 00010011, Decimal 18, Hexadecimal 11.

Movie: Recon, Digital Detectives

- “From homicide to computer hacking, DoD agents fight crime and support the mission of cyber security around the world with expertise in law enforcement and computer forensics”
- <https://youtu.be/EMDLUJkLXuE>

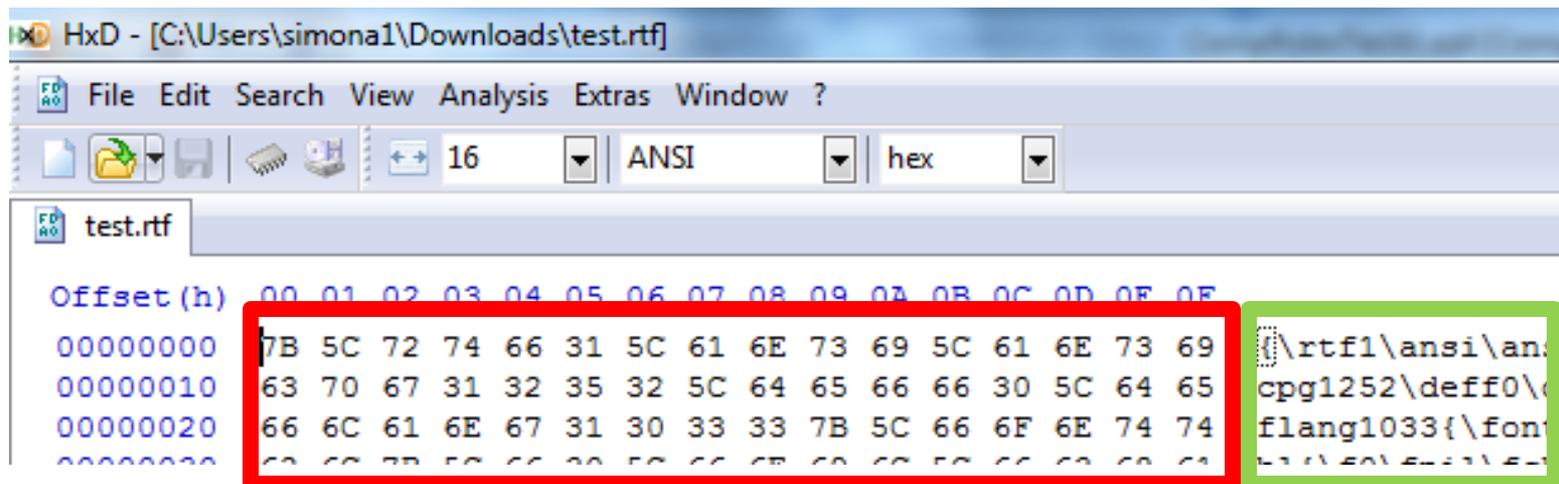


Computer Forensics

- **Computer Forensics** is reading and manipulating raw binary data in computer files
- While useful to hackers, is it most famously used in the investigation of computer crimes
- It is also used by individuals and businesses for data recovery

Hex Editors

- A Hex Editor will open *any* computer file.
- Hex Editors like HxD let you look directly at the binary data of a computer file.
- You'll see the same data shown two different ways:
 - Hex
 - ASCII



ASCII code

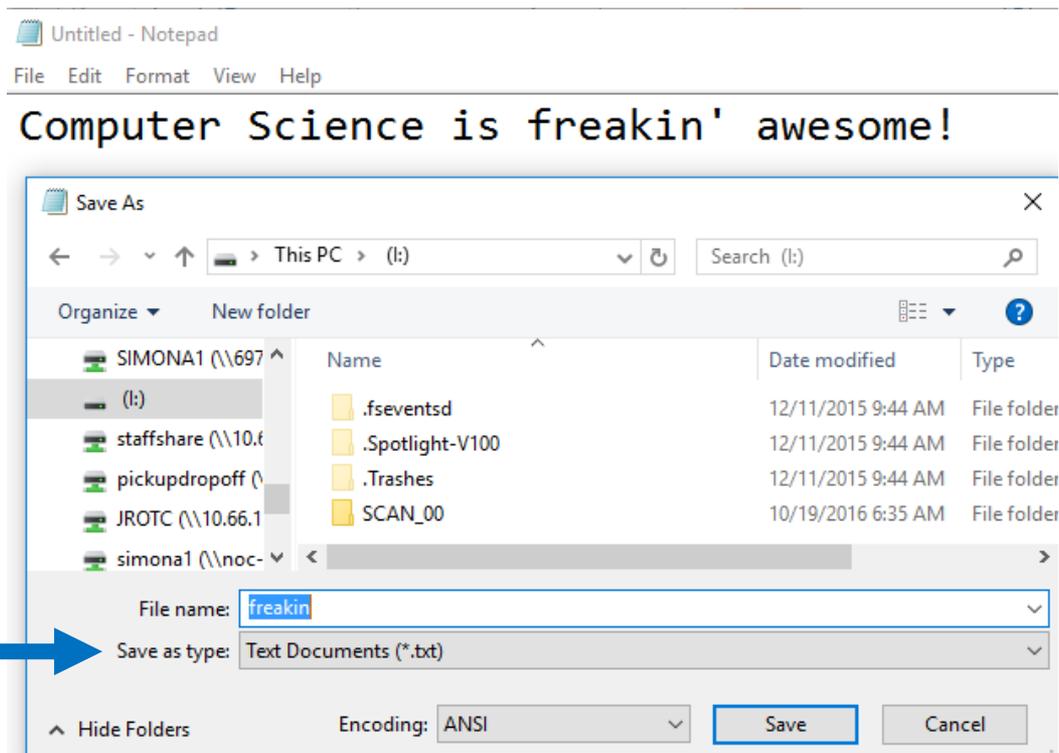
- If you are using a Hex Editor like HxD, you'll notice that for every **61** there is a lowercase a in the ASCII.

```
HxD - [C:\Users\simona1\Downloads\NETGEAR Wireless Adapter Cannot Connect to a WEP ASCII Secured Network.htm]
File Edit Search View Analysis Extras Window ?
16 ANSI hex
NETGEAR Wireless Adapter Cannot Connect to a WEP ASCII Secured Network.htm

Offset (h) 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
00000000 3C 21 44 4F 43 54 59 50 45 20 68 74 6D 6C 3E 0D <!DOCTYPE html>.
00000010 0A 3C 68 74 6D 6C 20 6C 61 6E 67 3D 22 65 6E 22 <html lang="en"
00000020 3E 0D 0A 3C 68 65 61 64 3E 0D 0A 3C 6D 65 74 61 >..<head>..<meta
00000030 20 63 68 61 72 73 65 74 3D 22 75 74 66 2D 38 22 charset="utf-8"
00000040 6E 0D 0A 0D 0A 09 3C 74 69 74 6C 65 3E 4E 45 54 >.....<title>NET
00000050 47 45 41 52 20 57 69 72 65 6C 65 73 73 20 41 64 GEAR Wireless Ad
00000060 61 70 74 65 72 20 43 61 6E 6E 6F 74 20 43 6F 6E apter Cannot Con
00000070 6E 65 63 74 20 74 6F 20 61 20 57 45 50 20 41 53 nect to a WEP AS
00000080 43 49 49 20 53 65 63 75 72 65 64 20 4E 65 74 77 CII Secured Netw
00000090 6F 72 6B 3C 2F 74 69 74 6C 65 3E 0D 0A 0D 0A 20 ork</title>....
000000A0 20 20 20 3C 6D 65 74 61 20 68 74 74 70 2D 65 71 <meta http-eq
000000B0 75 69 76 3D 22 63 6F 6E 74 65 6E 74 2D 74 79 70 uiv="content-typ
000000C0 65 22 20 63 6F 6E 74 65 6E 74 3D 22 74 65 78 74 e" content="text
000000D0 2F 68 74 6D 6C 3B 63 68 61 72 73 65 74 3D 55 54 /html; charset=UT
```

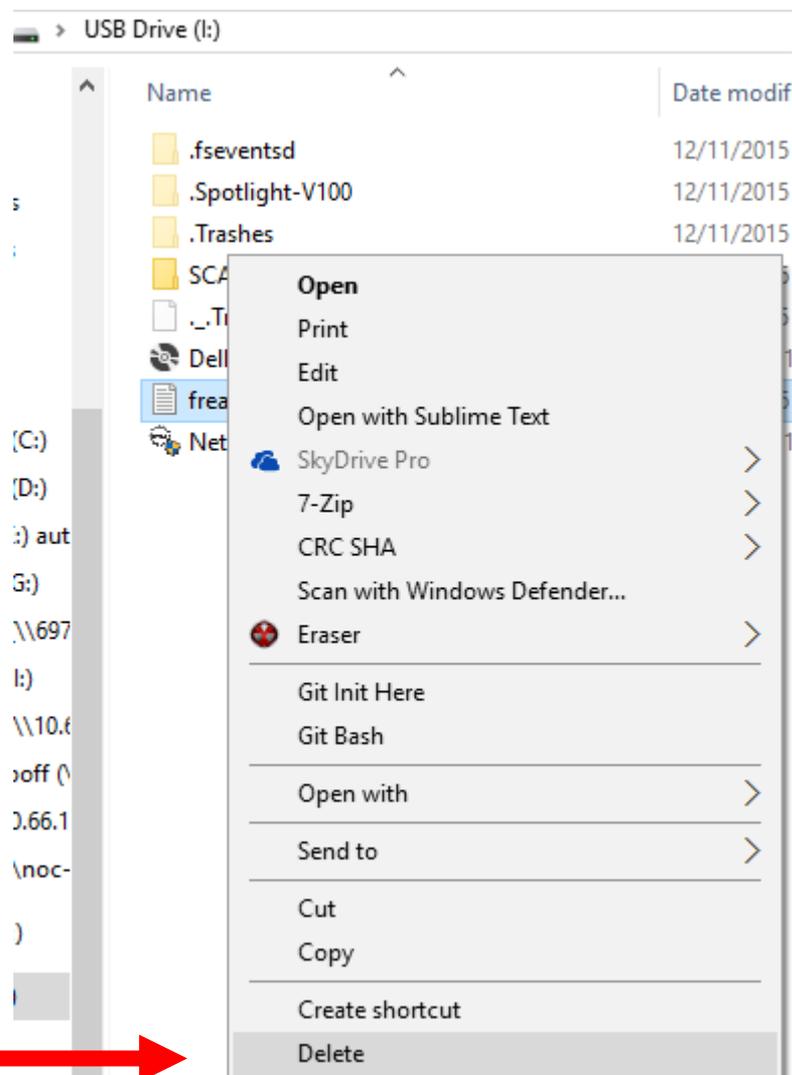
Using HxD to retrieve a deleted file

- This lab works best with a small thumb drive
- Create a **Text Document (*.txt)** with a distinctive word or two and save it to your thumb drive.



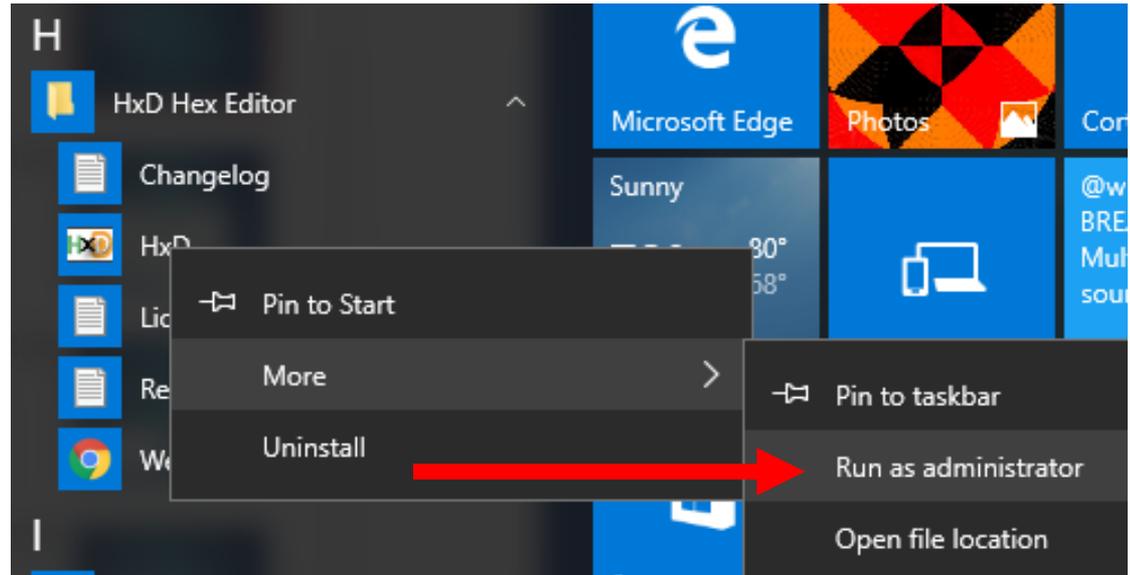
Using HxD to retrieve a deleted file

Now use File Explorer to **delete** the file from the thumb drive.



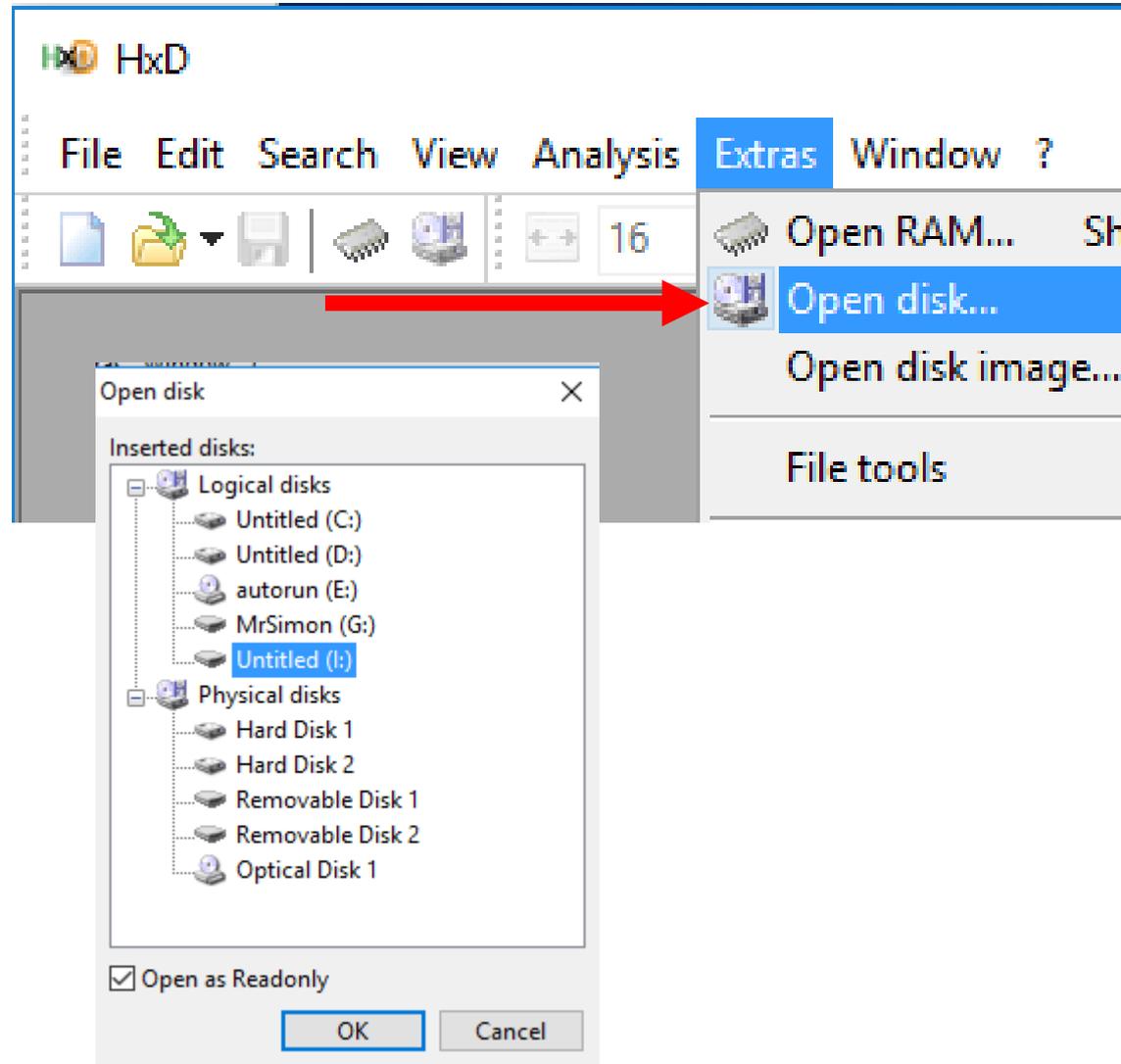
Using HxD to Retrieve a Deleted File

Right click on the HxD program and choose **More | Run As Administrator**.



Using HxD to Retrieve a Deleted File

- In HxD choose **Extras** | **Open disk**.
- Select your thumb drive and click **OK**.



How do Hard drives work?

- <https://www.youtube.com/watch?v=wteUW2sL7bc>



How do hard drives work? - Kanawat Senanan

Securing Private Data

- You buy a new computer.
- You transfer all your old files to the new computer.
- Your old computer has valuable private information that you don't want to fall into the wrong hands.
- What do you do with the hard drive from the old computer?

Best Practice: Destroy it with a Hammer



Securing Private Data

- Second best: data wiping software.
- Eraser is a good free program.



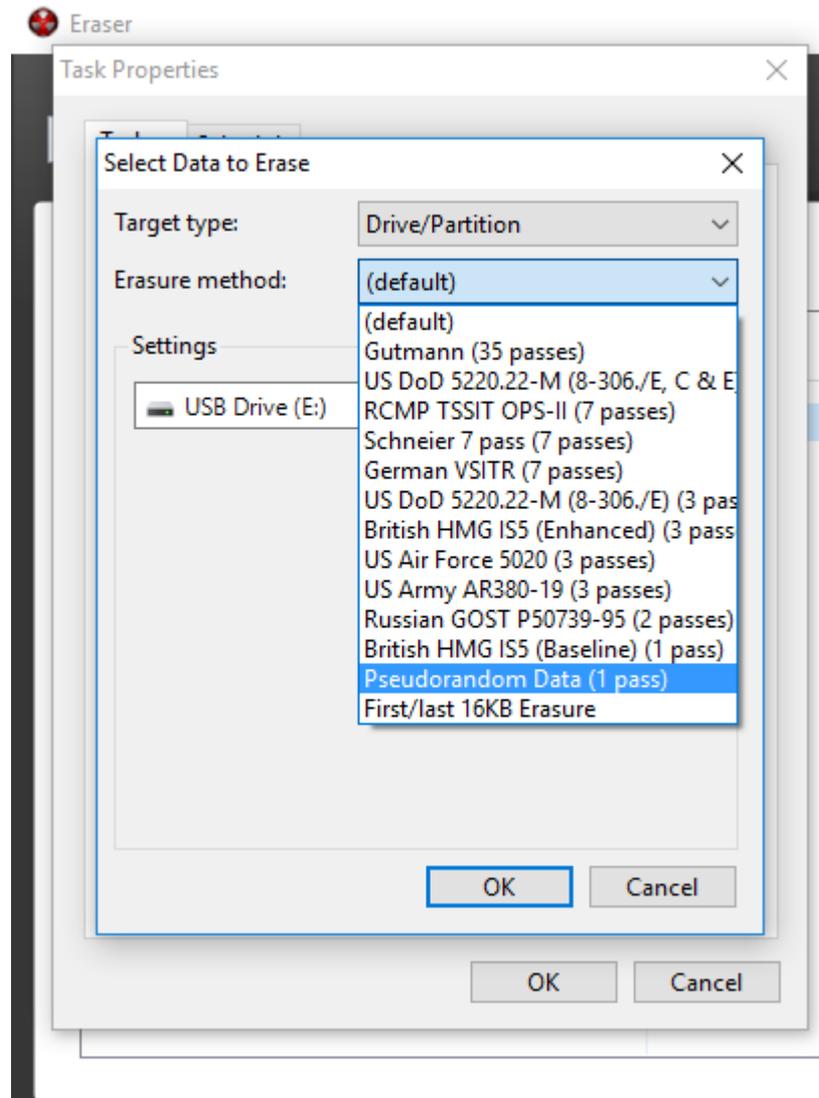
Before



```
E5 37 00 30 00 37 00 2E 00 74 00 0F 00 4A 78 00  å7.0.7...t...Jx.  
74 00 2E 00 64 00 6F 00 63 00 00 00 78 00 00 00  t...d.o.c...x...  
E5 30 37 54 58 54 7E 31 44 4F 43 20 00 29 B3 3E  å07TXT~1DOC .)³>  
55 49 55 49 00 00 B4 3E 55 49 16 00 7E 2C 00 00  UIUI..´>UI..~,..  
E5 30 37 20 20 20 20 20 54 58 54 20 10 5E E0 3E  å07      TXT .^à>  
55 49 55 49 00 00 E1 3E 55 49 00 00 00 00 00 00  UIUI..á>UI.....  
E5 30 37 20 20 20 20 20 54 58 54 20 10 5E E0 3E  å07      TXT .^à>  
55 49 55 49 00 00 E1 3E 55 49 16 00 10 00 00 00  UIUI..á>UI.....  
E5 62 00 69 00 6E 00 67 00 20 00 0F 00 16 62 00  åb.i.n.g. ....b.  
6F 00 6E 00 67 00 2E 00 74 00 00 00 78 00 74 00  o.n.g...t...x.t.  
E5 49 4E 47 42 4F 7E 31 54 58 54 20 00 76 6D 3F  åINGBO~1TXT .vm?  
55 49 55 49 00 00 6E 3F 55 49 00 00 00 00 00 00  UIUI..n?UI.....  
E5 62 00 69 00 6E 00 67 00 20 00 0F 00 16 62 00  åb.i.n.g. ....b.  
6F 00 6E 00 67 00 2E 00 74 00 00 00 78 00 74 00  o.n.g...t...x.t.  
E5 49 4E 47 42 4F 7E 31 54 58 54 20 00 76 6D 3F  åINGBO~1TXT .vm?  
55 49 55 49 00 00 6E 3F 55 49 00 00 00 00 00 00  UIUI..n?UI.....
```



- Here I've chosen to fill the USB drive with ***Pseudorandom Data***.



After



B2	85	8C	6A	C1	3D	83	66	DC	5C	67	D9	6F	8F	6E	CB	°...ŒjÁ=fÜ\gÜo.nĚ
1D	37	B4	A7	B9	8D	9A	BC	71	96	59	FD	7E	A2	95	B3	.7'Š².š4q-Yý~e•²
6F	60	5F	BD	BC	A7	A2	09	9D	98	31	D3	8B	8E	0F	C0	o`_44še..~1Ó<Ž.À
0B	E2	1B	5D	80	61	42	69	5F	B8	26	33	FF	9A	DD	89	.ã.]€aBi_,&3ÿšÝ%
90	27	16	A3	FF	43	55	35	5B	D8	57	ED	BA	F4	B3	F1	.'.£ÿCU5[ØWí°ó²ñ
2D	58	F8	58	9B	33	82	E1	8B	67	97	13	B7	20	26	21	-XøX>3,á<g-. · &!
38	08	8A	3E	CC	7E	35	B9	CF	BF	25	7A	1F	53	60	7A	8.Š>Î~5²İ¿%z.S`z
54	04	CD	8B	A4	22	25	69	7A	A8	ED	73	E7	2D	3C	0C	T.Í<«"šiz`ísç-<.
67	91	5B	C4	99	91	7B	BE	B8	D7	97	DE	66	9C	A8	3D	g`[Ä³`{¼,x-þfœ`=
06	5B	48	09	64	E6	93	5F	BC	C4	26	1F	16	0C	BE	FF	.[H.dæ"¼Ä&...¼ÿ
83	16	D1	B5	71	24	24	5A	B1	8B	6F	BC	93	33	6C	FA	f.Ńuq\$\$\$Z±<o4"3lú
E8	21	A0	13	8F	A3	F7	31	E8	9C	74	CD	D0	19	6A	88	è! ..£÷1èœtÍĐ.j`
4F	C3	2F	9C	D4	0C	BE	72	2B	69	1A	94	4F	B5	FF	C2	OÄ/œÖ.¼r+i."OuÿÄ
C5	1E	DB	D3	1C	52	41	56	04	CF	F9	CB	26	95	94	FA	Å.ÛÓ.RAV.İùĚ&•"ú
EB	7D	FC	97	65	3D	B4	72	F2	3B	C8	8E	17	7C	9F	BF	è)ù-e=´rò;ÈŽ. ÿ¿
09	41	66	EF	FF	ED	6B	21	C6	10	41	2A	AA	3F	E0	46	.Afiÿik!Ě.A*²?àF
E0	5E	CC	9A	94	80	C2	56	70	39	F0	8F	26	E3	D6	5E	à^İš"€ÄVp9ð.šãÖ^
DE	7C	A5	70	AA	EC	A9	0A	C9	B7	24	58	2E	CF	70	C0	þ ¼pªi©.É·\$X.İpÀ
C1	62	F6	F4	D7	D9	4F	D6	32	7B	7A	7E	B4	8A	AC	F9	Áböô×ÜÖ2{z~´Š-ù

Today's Computer Forensics Lab is from the 2013 Toaster Wars Competition



The premise of the competition is that a robot from space has crash landed in your backyard. It's up to you and your hacking skills to uncover the secrets he carries.



This is *ethical hacking*.
We have *permission* to access the files.



Ethical Hacking

- Sometimes called “white hat” hacking.
- The goal of the ethical hacker is to protect against malicious attacks by attacking the system while staying within legal limits.
- ***To catch a thief, think like a thief.***
- Ethical hackers work as computer security experts and consultants.

Computer Forensics Lab

- Download each of the three files, but **don't** double click.
- Open the files in HxD and look for clues.

Computer Forensics Lab 1

In part 1 of this lab you will solve three of the computer forensics problems from the Toaster Wars high school hacking competition (sometimes called a “capture the flag” competition or ctf for short).

The premise of the competition is that a robot from space has crash landed in your backyard. It's up to you and your hacking skills to fix him and uncover the secret he carries. You will need to run HxD on your computer. When you think you've found the answer show it to your instructor and then submit this completed document to the school loop drop box.

Problem #1: XML LOL

You have discovered a corrupted XML file from the robot's memory. Right click on the link, save the file to your computer and then use a hex editor like HxD to read the corrupted XML file. You are looking for a configuration key.

Enter the configuration key here _____

Computer Forensics Lab

Because the first xml file is corrupted, opening it in a browser will generate an error message.



This page contains the following errors:

error on line 3 at column 3: error parsing attribute name

Below is a rendering of the page up to the first error.

Computer Forensics Lab

- To download a file, right click on a link in the school assignment and choose *Save link as*.
- Then open HxD and choose *File | Open*.
- Go to your *Downloads* folder and choose the file.

word processing document and submit the document to the school loop drop box.

Attachments

Computer Forensics Lab 1 word processing document

Problem

Problem

Problem

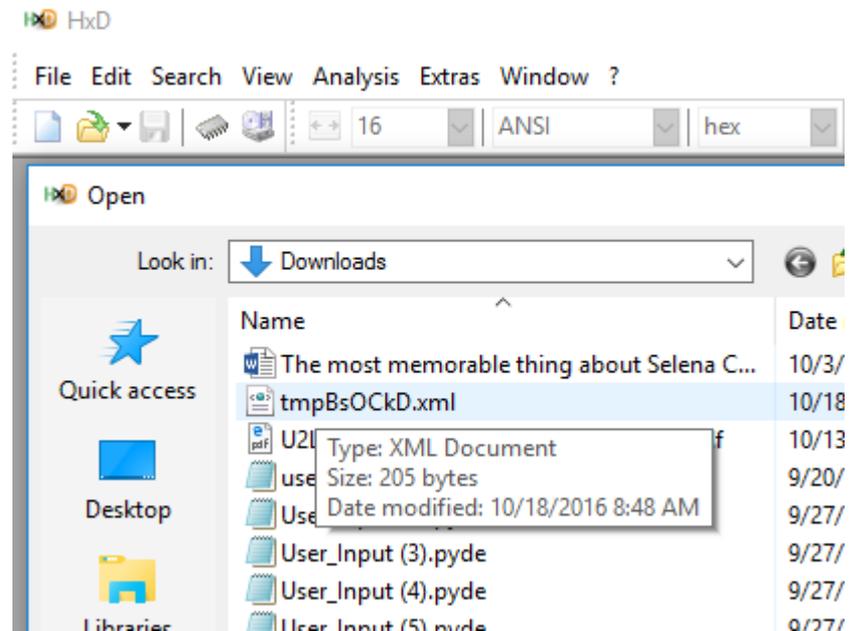
Discussion

Bytes

- Open link in new tab
- Open link in new window
- Open link in incognito window

Save link as...

Copy link address



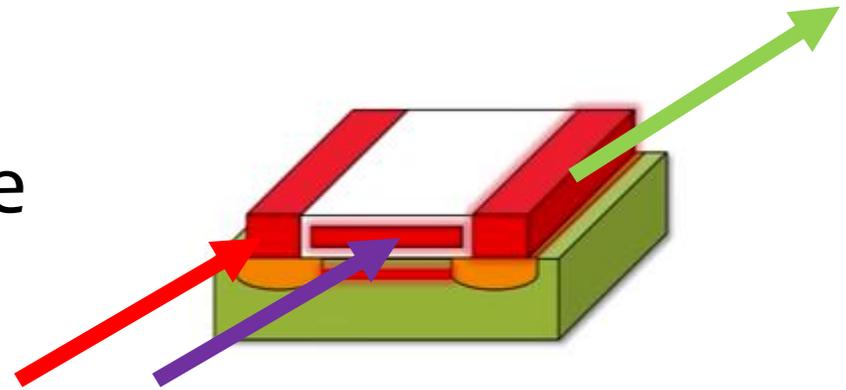
1s and 0s *on/off* switches and addition

- Many people don't realize the marks on *on/off* switches come from the binary system.
- **1** represents *on* and **0**. represents *off*.
- Computers use binary switches to do arithmetic.
- Video: [How computers add numbers](#)



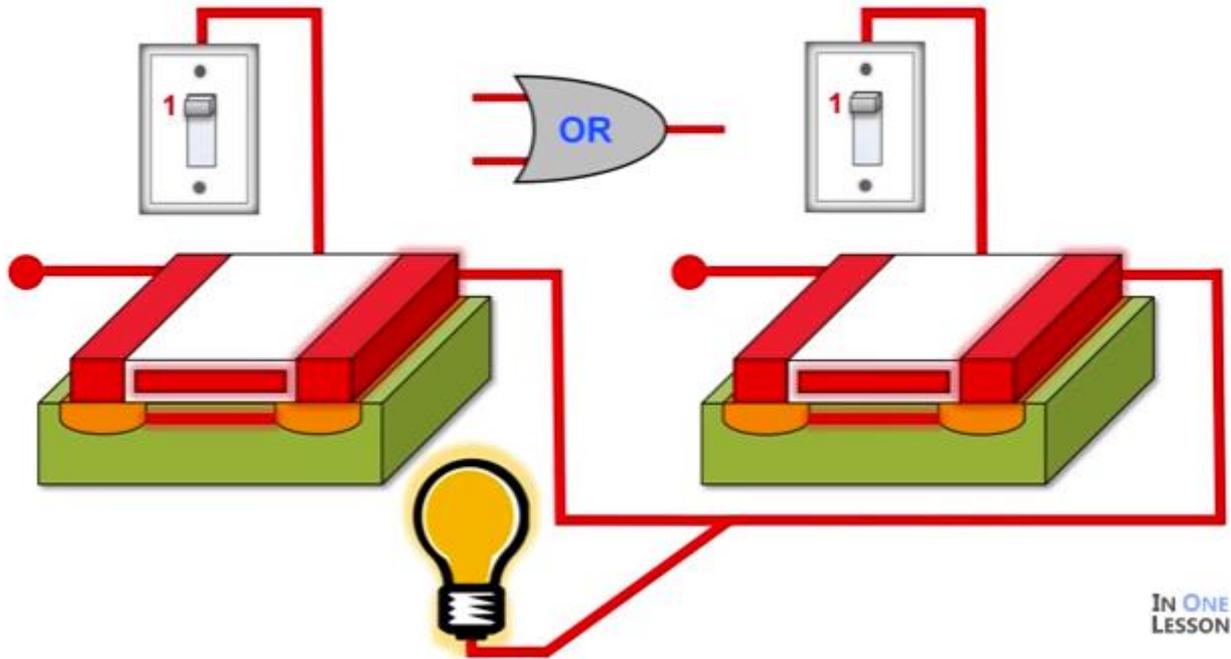
Transistors Can Act like a Switch

If both the **input** has power and the electricity to the **gate** is turned on, electricity will flow out the **drain**.



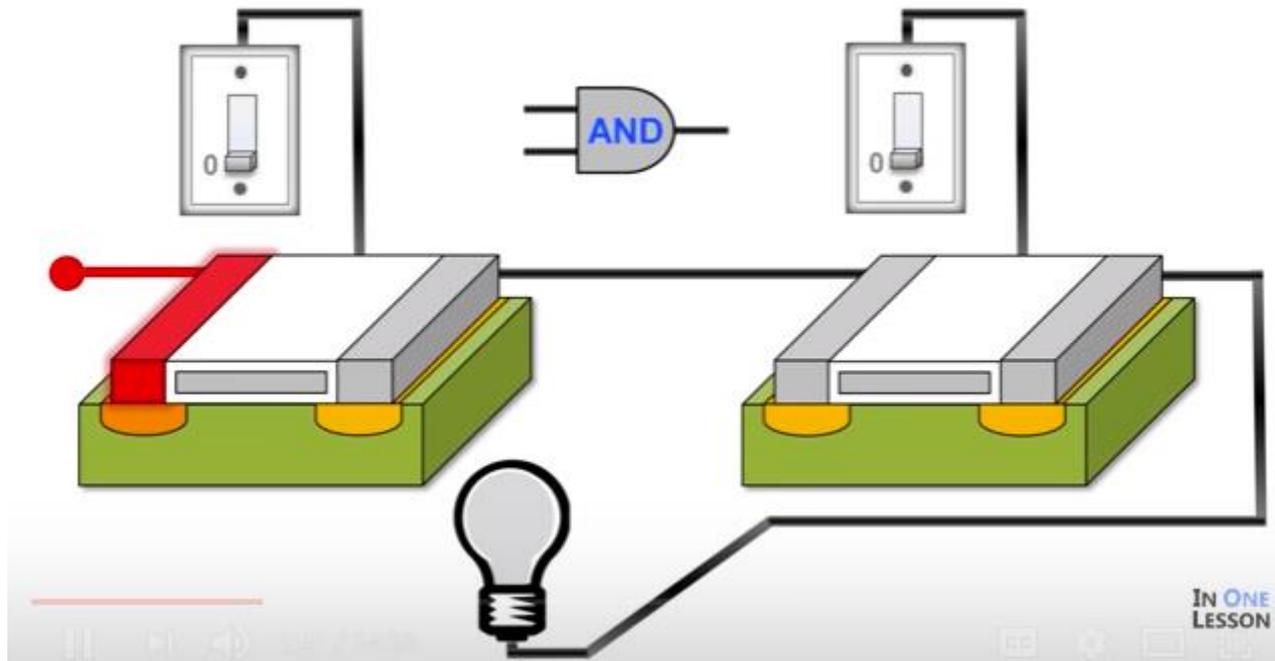
Or Gates

If either (or both) switches are on, the light will go on.



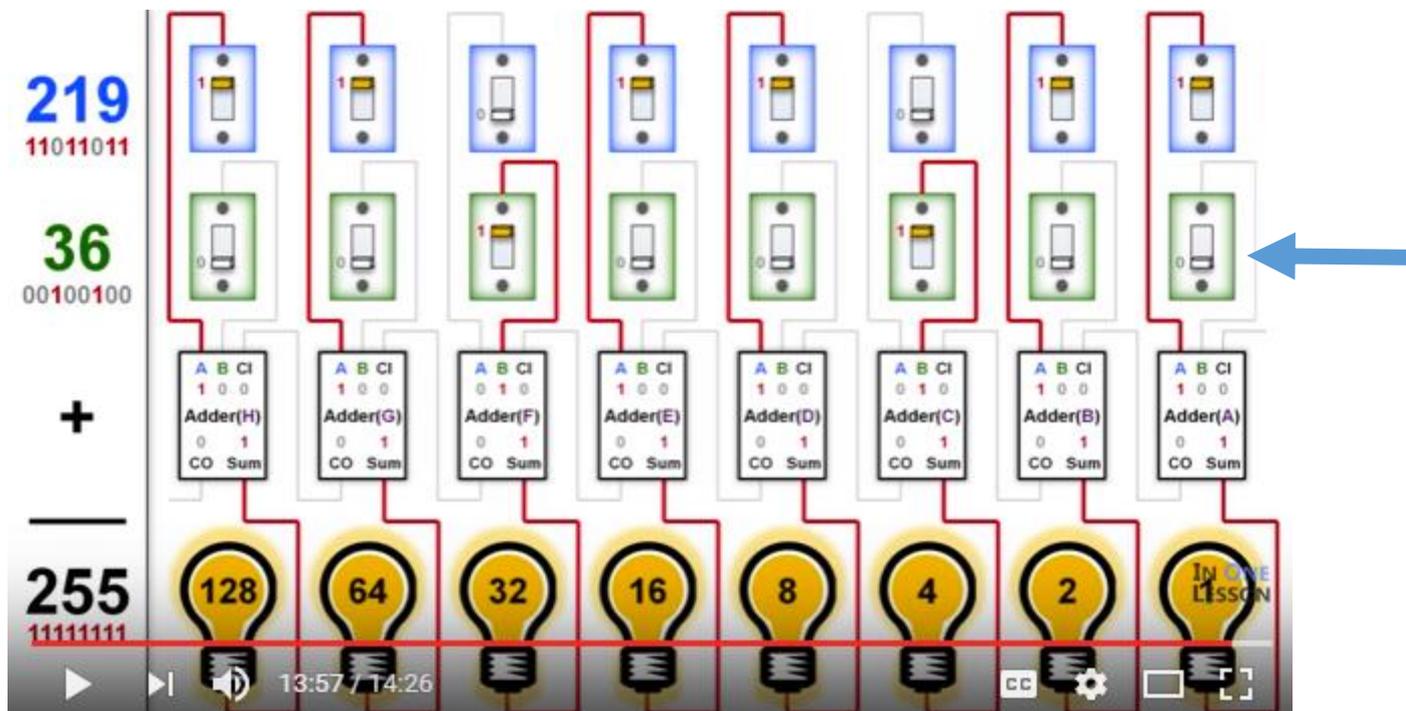
And Gates

The output of one transistor is connected to the input of the other. Both switches must be on to turn the light on.



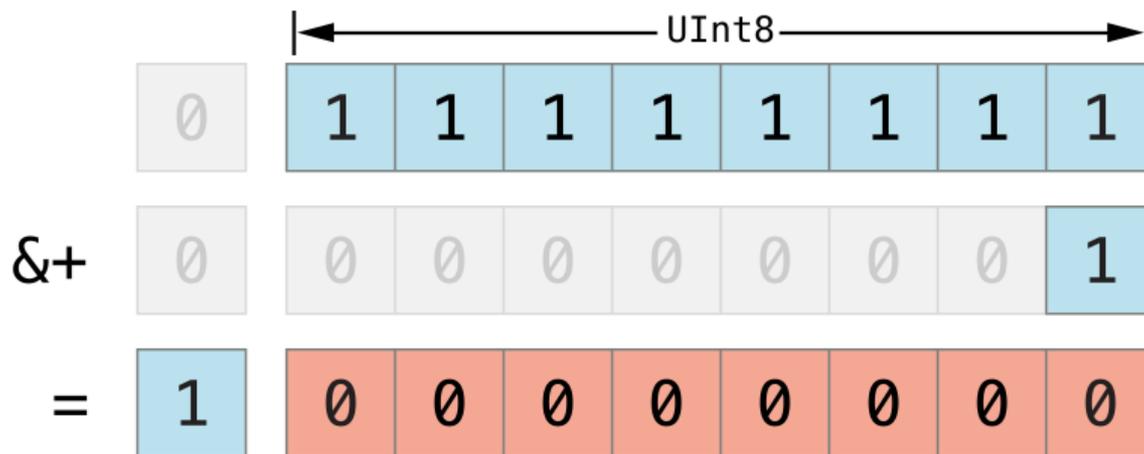
If 219 + 36 is 255 in 8 bits.
What is 219 + 37?

What would happen if I turned on **this switch** to make the number one bigger?



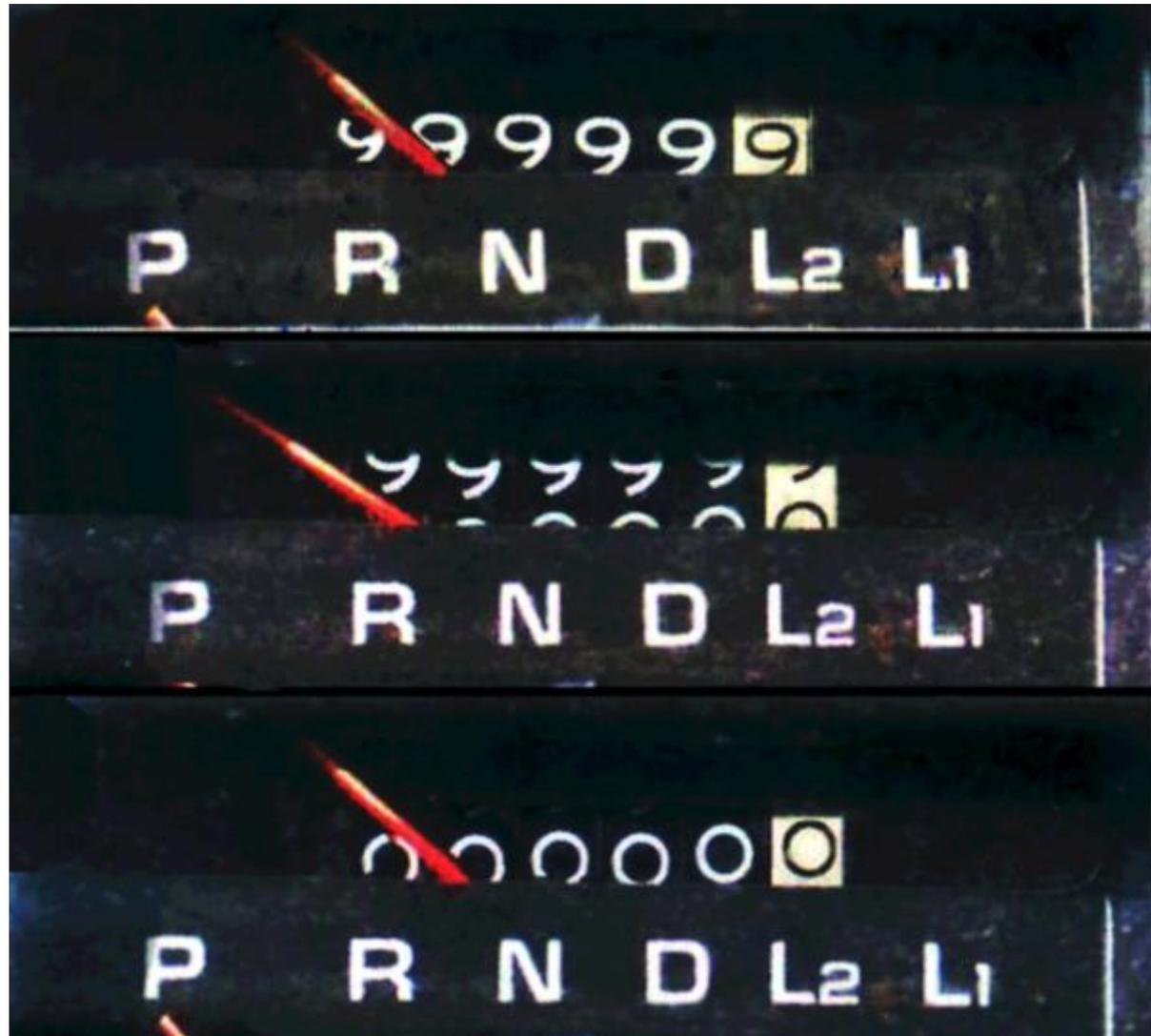
Overflow

- In an 8 bit number system, $255 + 1$ is zero!
- Adding one to the largest possible value “resets” the number back to the smallest possible value.



Overflow

One example of overflow is where a car's odometer "rolls over" from all 9s to all 0s.



Overflow Odometer Widget

<https://studio.code.org/s/odometer/stage/1/puzzle/1>

The screenshot shows the 'Odometer Widget' interface in Code.org Studio. At the top, there are four colored squares (C, O, D, E) and the text 'STUDIO'. The title 'Odometer Widget' is displayed in a teal bar with a '1' in a circle. Below the title, there is a paragraph of instructions: 'Use the widget below to control odometers with various number bases. Binary, Decimal and Hexadecimal are the most common. Practice with them here. Set a value. Predict what the number one up, or one down will be.'

The interface includes three buttons: 'Start', 'Pause', and 'Reset'. Below these is a speed slider ranging from 'Slow' to 'Fast'. There are five odometer displays, each with a label and a set of colored segments:

- Binary: 1 0 1 0 0 0 1 1 0
- Octal: 5 0 6
- Decimal: 3 2 6
- Hexadecimal: 1 4 6
- Custom Base: 20, G 6

At the bottom, there is a 'Value:' input field containing '326' and a range slider from 'Min' to 'Max'. An orange 'Continue' button is located at the bottom left.

Overflow in Java

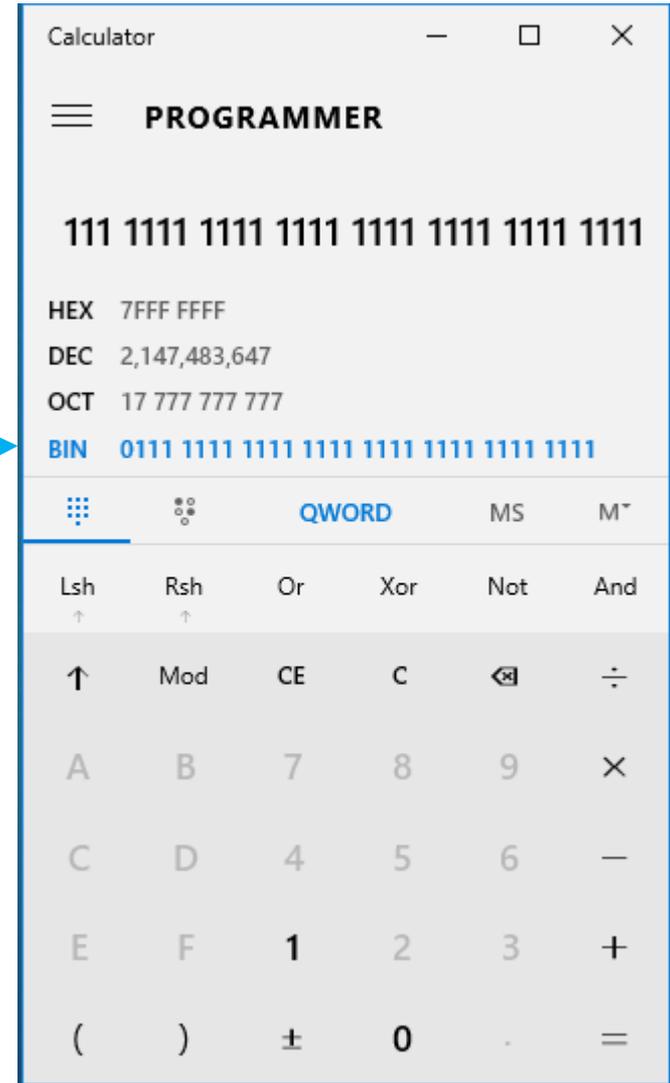
- Java uses signed 32 bit integers.
- This basically means you need one bit to store whether the integer is positive or negative.
- 31 bits are left to store the value of the integer.
- How big a value can you store in 31 bits?



The screenshot shows the Processing IDE interface. At the top, the title bar reads "sketch_161018a | Processing 3.2.1". Below the title bar is a menu bar with "File", "Edit", "Sketch", "Debug", "Tools", and "Help". The main editor area shows a code snippet on line 1: `print(2147483647 + 1);`. The code is highlighted in light blue. Below the editor is a console window showing the output: `-2147483648`. The console window has a dark background and a light border. At the bottom of the IDE, there are two buttons: "Console" and "Errors".

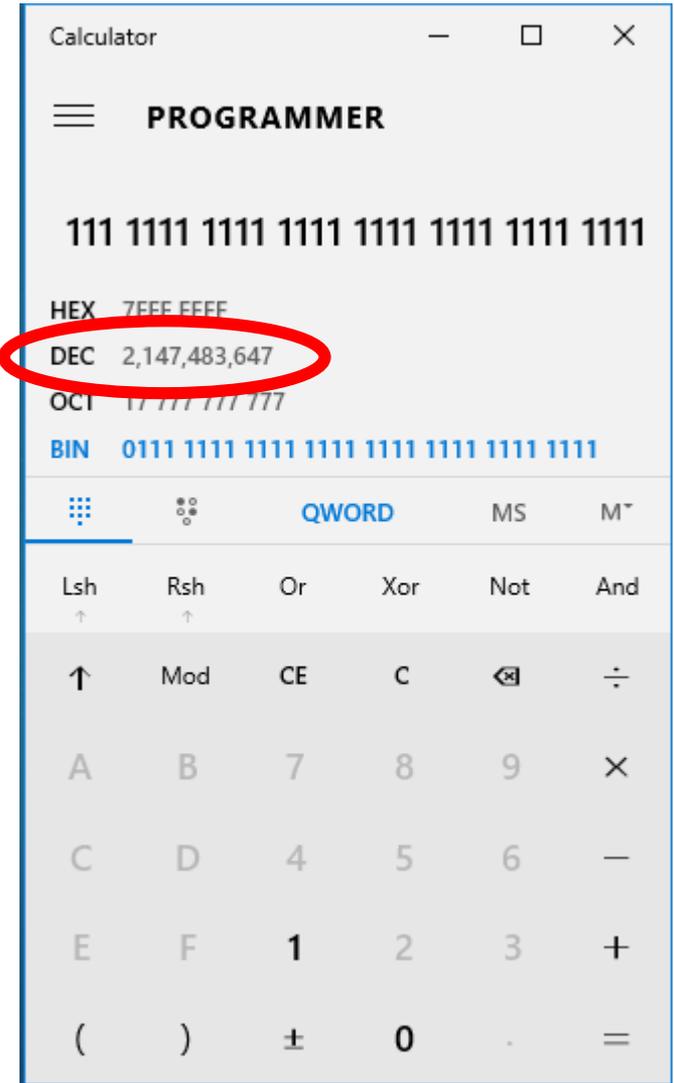
31 bits

One way to calculate the largest value can you store in 31 bits is to type 31 1s in **binary mode** in the windows calculator.



31 bits

- How big a value can you store in 31 bits?
- 2,147,483,647



Overflow in Java

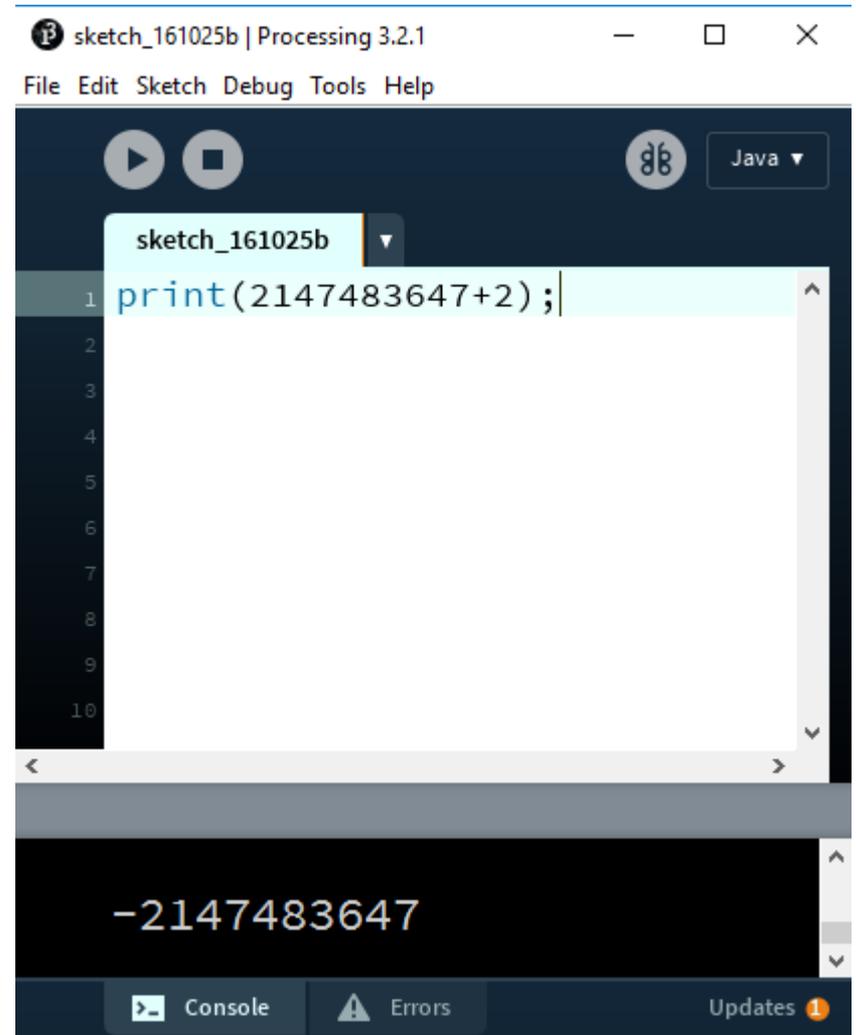
- Adding 1 to 2,137,483,647 in Java causes an **overflow** error.
- We get -214748368 for an answer.
- That's the **smallest** number you can have in a signed 32 bit system.



The screenshot shows the Processing IDE interface. At the top, the title bar reads "sketch_161018a | Processing 3.2.1" and the menu bar includes "File Edit Sketch Debug Tools Help". The code editor shows a single line of code: `print(2147483647 + 1);`. Below the code editor, the console window displays the output: `-2147483648`. The console window also has "Console" and "Errors" tabs.

Overflow in Java

2137483647 + 2 is
-2147483647 in Java!



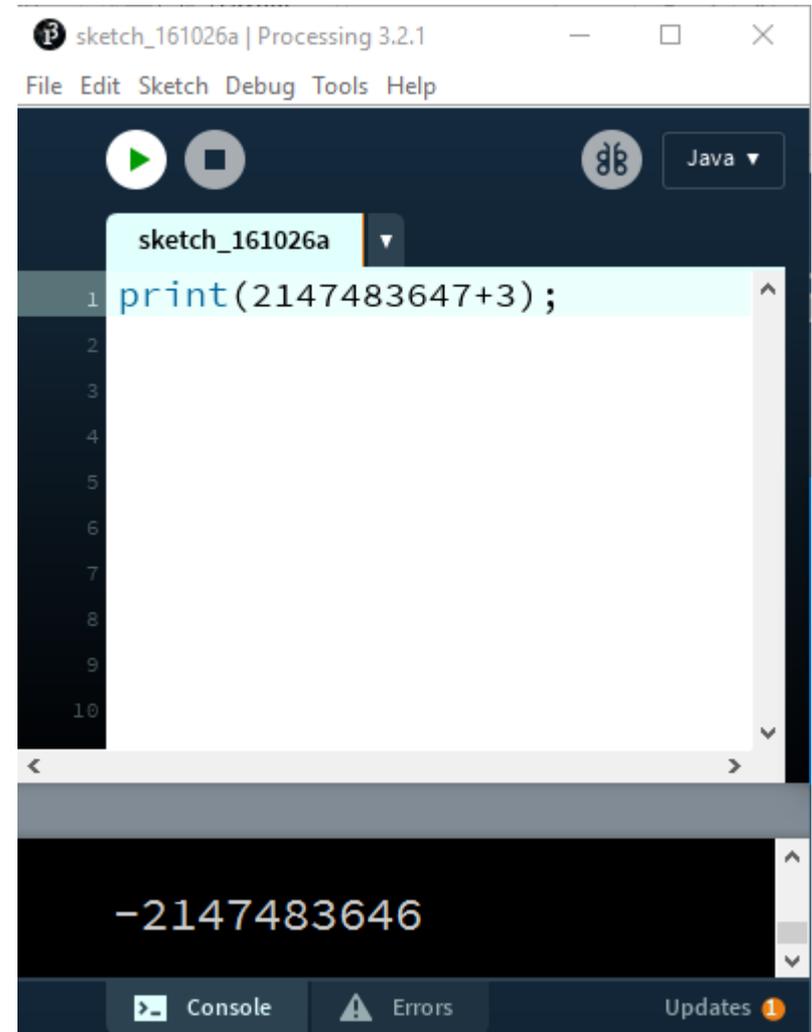
The screenshot shows the Processing IDE interface. The title bar reads "sketch_161025b | Processing 3.2.1". The menu bar includes "File", "Edit", "Sketch", "Debug", "Tools", and "Help". The main editor area shows a Java sketch with the following code:

```
1 print(2147483647+2);
```

The output window at the bottom displays the result of the calculation: `-2147483647`. The IDE also shows a "Console" tab and an "Errors" tab, along with an "Updates" button.

Overflow in Java

2137483647 + 3 is
-2147483646 in Java!

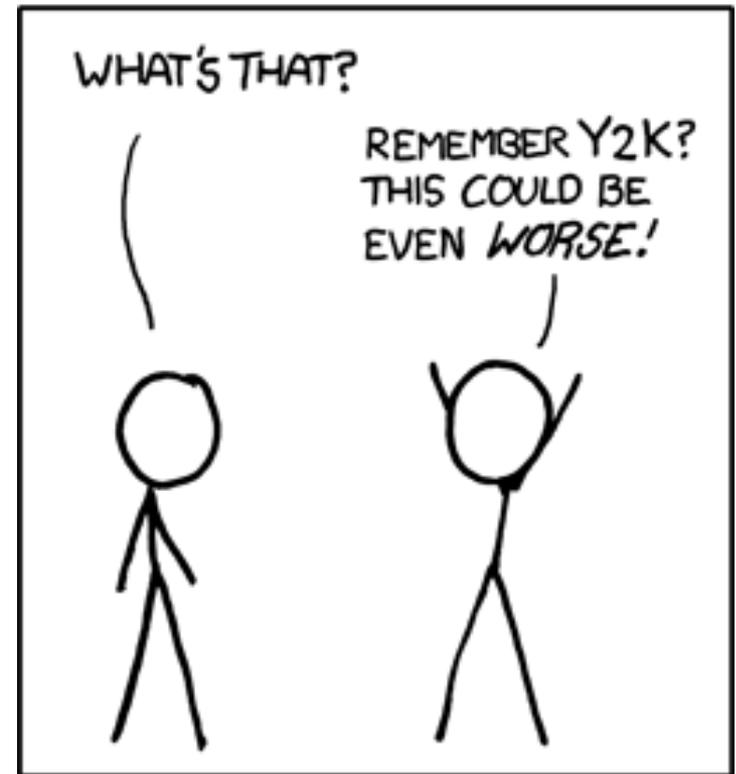


The screenshot shows the Processing IDE interface. The title bar reads "sketch_161026a | Processing 3.2.1". The menu bar includes "File", "Edit", "Sketch", "Debug", "Tools", and "Help". The main editor area contains a single line of code: `print(2147483647+3);`. Below the editor, the console window displays the output: `-2147483646`. The IDE also shows a "Java" dropdown menu and a "Console" tab at the bottom.

2038 Problem

- In many UNIX computers time values are stored as a signed 32-bit integer.
- This number is interpreted as the number of seconds since 00:00:00 UTC on 1 January 1970.
- In 2038, these computers will run out of seconds.
- Their time variables will overflow and reset to a negative value (somewhere around 1902!).

I'M GLAD WE'RE SWITCHING TO 64-BIT, BECAUSE I WASN'T LOOKING FORWARD TO CONVINCING PEOPLE TO CARE ABOUT THE UNIX 2038 PROBLEM.



Gangnam Style

- YouTube used to use signed 32 bit integers on their UNIX computers to keep track of page views.
- Gangnam style forced them to upgrade to a 64 bit system.



Overflow Lab

- Use the code.org odometer widget and the **Java mode** in Processing to complete the worksheet.
- If you need help answering question #6, read the story [Why does Donkey Kong break on level 22?](#)
- Save your work and submit it to school loop by choosing **Submit From: Device**.

Overflow
AP Computer Science Principles Name _____

Visit the [Code.org](http://studio.code.org/is/odometer/stage/1/puzzle/1) odometer widget at
<http://studio.code.org/is/odometer/stage/1/puzzle/1> Press



Use the widget below to control odometers with various number bases. Binary, Decimal and Hexadecimal are the most common. Practice with them here. Set a value. Predict what the number one up, or one down will be.

Start Pause Reset

Slow Fast

Binary: 1 0 1 0 0 0 1 1 0

Octal: 5 0 6

Decimal: 3 2 6

Hexadecimal: 1 4 6

Custom Base: 70

Value: 326

Min Max

Continue

Press Start and experiment with Slow Fast and Min Max controls. Write your answers to the following questions in the provided blanks.

How many bits are in the binary odometer? _____

What is the largest value the binary odometer can hold before it overflows?

What is the decimal value of that largest binary number? _____

Logic.ly

- A program for building circuits with logic gates.
- Use the free demo version at <http://logic.ly/demo>



Pricing & Purchase

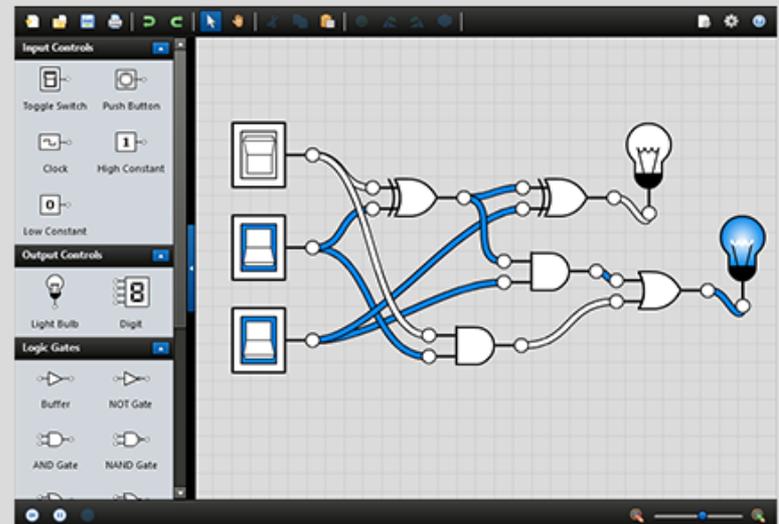
Download the Free Trial

Teach logic gates + digital circuits effectively — with Logicly

- Design circuits quickly and easily with a modern and **intuitive user interface** with drag-and-drop, copy/paste, zoom & more.
- Take control of **debugging** by pausing the simulation and watching the signal propagate as you advance step-by-step.
- Don't worry about **multiple platforms** on student computers. Install on both Windows and Mac.

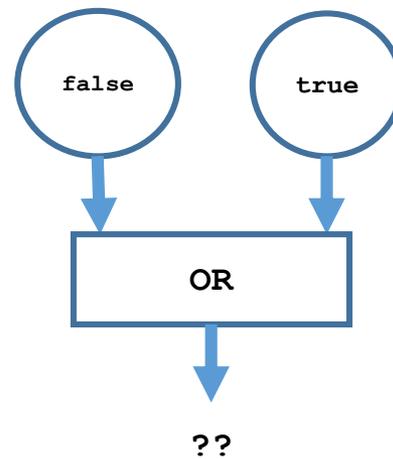
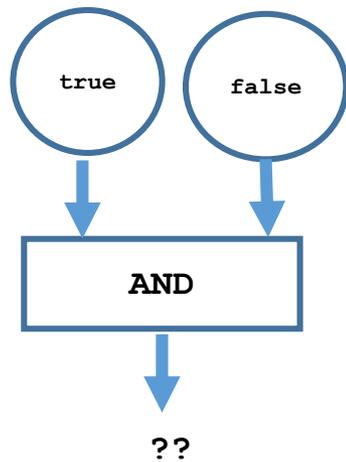
Buy Logicly

Free Trial



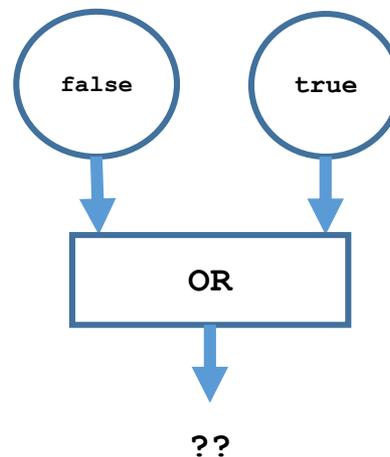
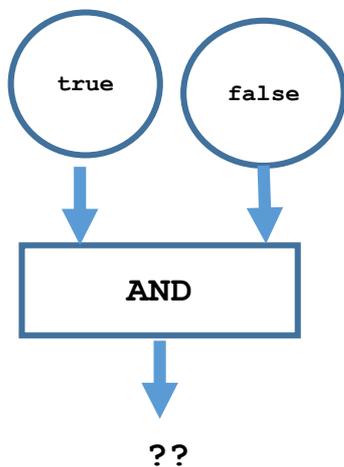
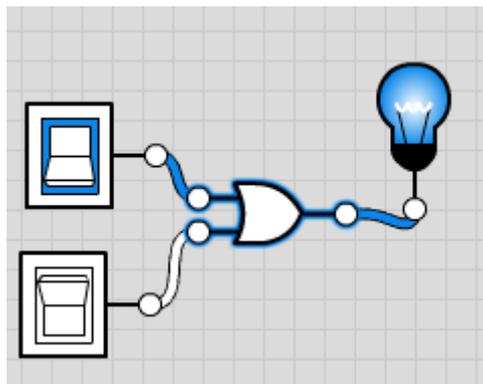
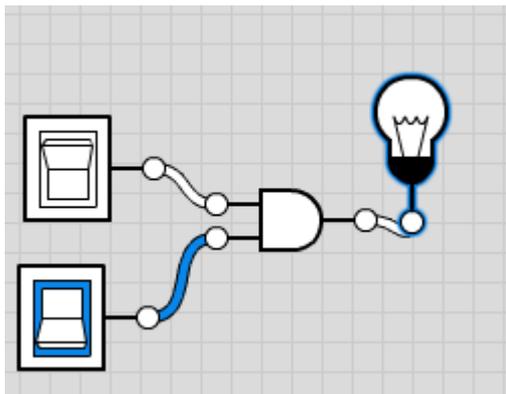
AND and OR Gates on the AP exam

What would be the value of the two outputs?



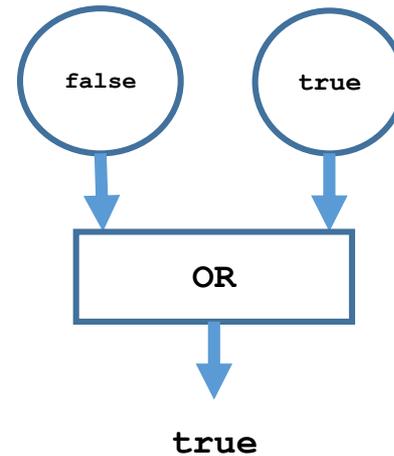
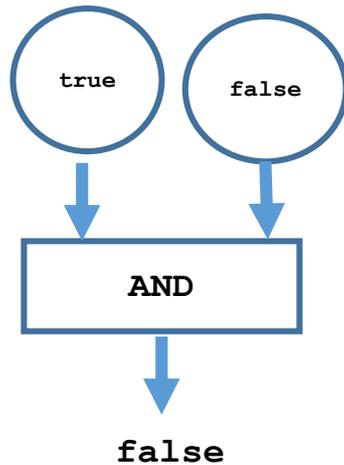
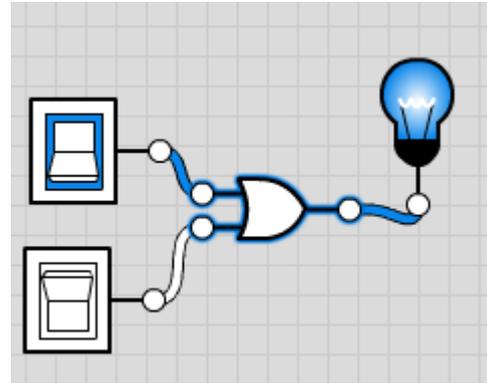
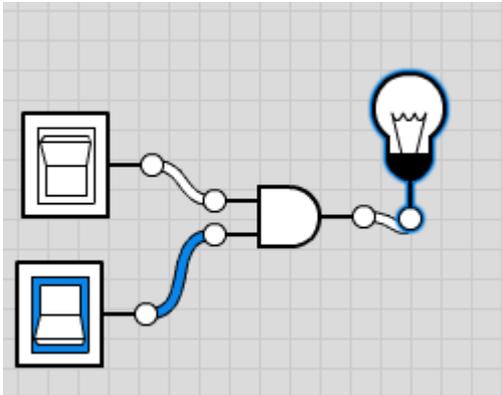
AND and OR Gates on the AP exam

We can check by building the circuits in Logic.ly.

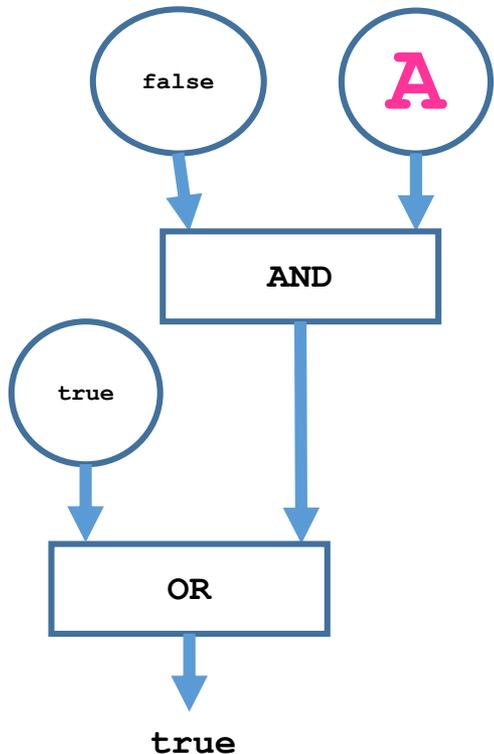


AND and OR Gates on the AP exam

We can check by building the circuits in Logic.ly.



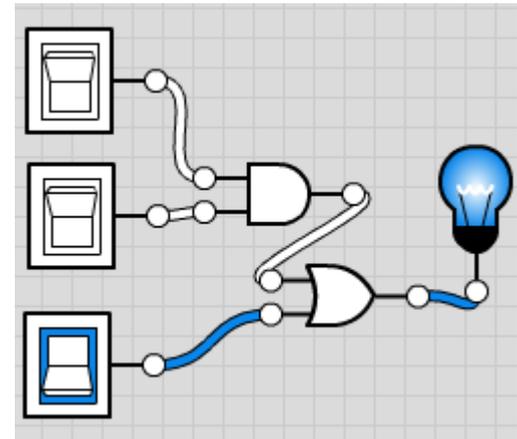
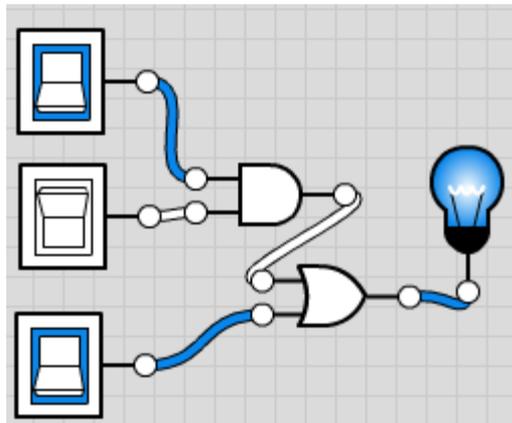
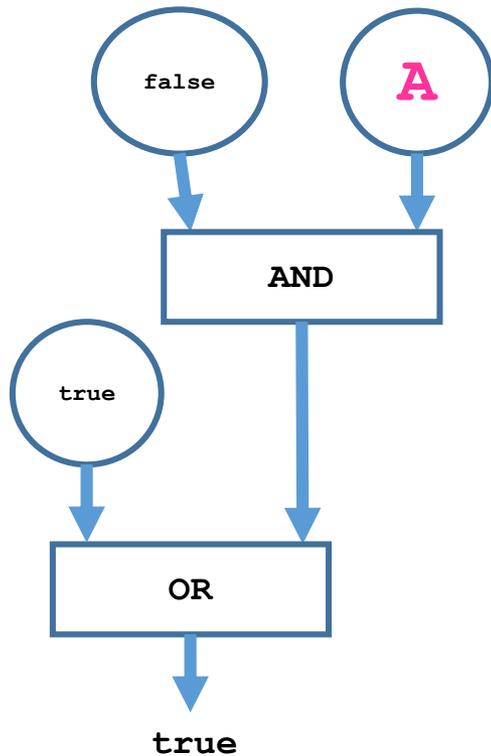
Practice Quiz Question: What is the value of **A**?



- A. True
- B. False
- C. Either **True** or **False**
- D. There is no value of **A** that will make the output of the circuit **True**

Check your answer by building the circuit at <http://logic.ly/demo>

The answer is C: **A** can be either True or False
We can confirm this by switching the top switch on and off.



Logic Gate lab

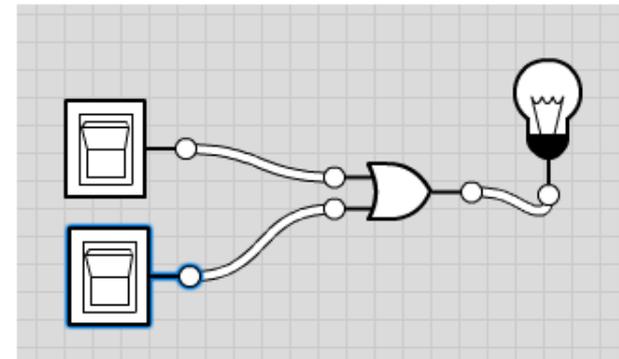
- Build and test circuits that use AND and OR gates.
- The AP exam does not test other types of logic gates.
- Use the snipping tool to show that you have built the circuit.

Logic Gates in Logic.ly AP Computer Science Principles

Go to <https://logic.ly/demo/> to complete this assignment.

Name _____

1. Build the circuit shown below using two toggle switches, one OR gate and one light bulb. Make sure you are using an OR gate and not a NOR gate as shown in the picture on the right. Connect the components by clicking and dragging the white dots. The two toggle switches are shown in the *off* or 0 position. This position can be interpreted as *false*. Pressing either switch will toggle them back and forth from *on* 1 to *off* 0. The *on* 1 position can be interpreted as *true*. Use the Windows snipping tool to paste a picture of your circuit next to the picture below.



2. Use your circuit to complete following truth table for an OR gate. Mark *true* if the light bulb is *on* and *false* if the light bulb is *off*.

Abbr In Ur Txt Msgs

- When you send text messages to a friend, do you spell every word correctly?
- Do you use abbreviations for common words? Name as many as you can.
- What are some examples of things you might see in a text message that are not proper English?
- Why do you use these abbreviations? What is the benefit?

Compression: Same Data, Fewer Bits

- When you abbreviate or use coded language to shorten the original text, you are “compressing text.” Computers do this too, in order to save time and space.
- The art and science of compression is about figuring out how to represent the SAME DATA with FEWER BITS.
- Why is this important?
 - Fewer bits take up less room on your hard drive, phone, camera, etc.
 - Fewer bits can be transmitted faster

Decode this Message!

In class take a few minutes to decode the message and write your answer on [this worksheet](#).

Unit 2 Lesson 2

Name(s) _____ Period _____ Date _____

Activity Guide: Decode this message!



What's the original message?

Below is an encoded message. It's not necessarily a secret message but it does need to be decoded. Study the clues and key to reconstruct the original message.

Encoded Message:

★listen_to☀rain_★on☀window_pane

Original Message:

Key:

☀	_the_
☂	tter_
☃	Pi☂
☂	Pa☂
★	☃☂☃☂

How Many Characters Were Saved?

- The encoded message is only part of the entire message.

Original Message 93 characters

Pitter_patter_pitter_patter_listen_to_the_rain_pitter_patter_pitter_patter_on_the_window_pane

Encoded Message:

★listen_to☀rain_★on☀window_pane

31 characters

- If you were to just send the encoded message to someone they would not be able to decode it.
- The full compressed message includes BOTH the encoded message and **the key to solve it.**

Key:

☀	_the_
☂	tter_
☔	Pi☂
☔	Pa☂
★	☔☔☔

Calculating the Compression Ratio

To calculate the compression ratio you must compare the total number of characters in the encoded message **plus** the total number of characters in the key.

The formula to calculate the compression ratio is $100\left(\frac{u-c}{u}\right)$ where c and u are the sizes of the Compressed and Uncompressed Files.

How Much? 40% compressed!

Original:	93 characters
Compressed:	56 characters
Difference:	37 characters (~40%)

Original Message 93 characters

Pitter_patter_pitter_patter_listen_to_the_rain_pitter_patter_pitter_patter_on_the_window_pane

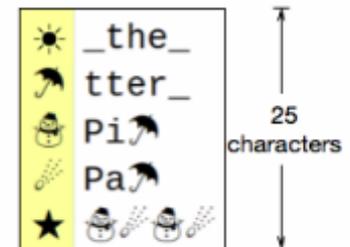
Compressed 56 characters

★listen_to★rain_★on★window_pane

← 31 characters →

Total number of characters needed to represent compressed version is:

31 (message) + 25 (key) = 56



40%

- $100\left(\frac{u-c}{u}\right)$
- $= 100\left(\frac{93-56}{93}\right)$
- $= 100(.3978)$
- $\approx 40\%$

The formula to calculate the compression ratio is $100\left(\frac{u-c}{u}\right)$ where c and u are the sizes of the Compressed and Uncompressed Files.

How Much? 40% compressed!

Original:	93 characters
Compressed:	56 characters
Difference:	37 characters (~40%)

Original Message 93 characters

Pitter_patter_pitter_patter_listen_to_the_rain_pitter_patter_pitter_patter_on_the_window_pane

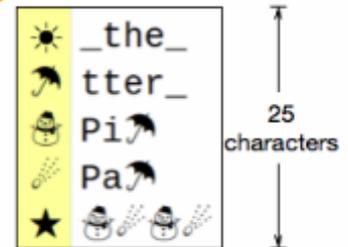
Compressed 56 characters

★listen_to★rain_★on★window_pane

← 31 characters →

Total number of characters needed to represent compressed version is:

31 (message) + 25 (key) = 56



Text Compression Widget with Aloe Blacc

- <https://www.youtube.com/watch?v=LCGkcn1f-ms&feature=youtu.be>



Text Compression Worksheet

Type your answers on this [worksheet](#) as you work with the [Code.org text compression widget](#).

Unit 1 Lesson 13

Name(s) _____ Period _____ Date _____

Activity Guide - Text Compression



Objectives

Compress a piece of text using the Text Compression Widget (lossless compression scheme)

- Explain the factors that make compression challenging.
- Explain why the “best” compression is impossible or “hard” to identify.
- Create your own heuristic for compressing data.

Vocabulary

Compress: to decrease the number of bits used to represent a piece of information

Algorithm: a precise sequence of instructions designed to complete a task

Heuristic: a specific type of algorithm, usually used when exact solutions are difficult or impossible. Heuristics are generally simple to use and are designed to provide reasonably good results without guaranteeing a perfect solution.

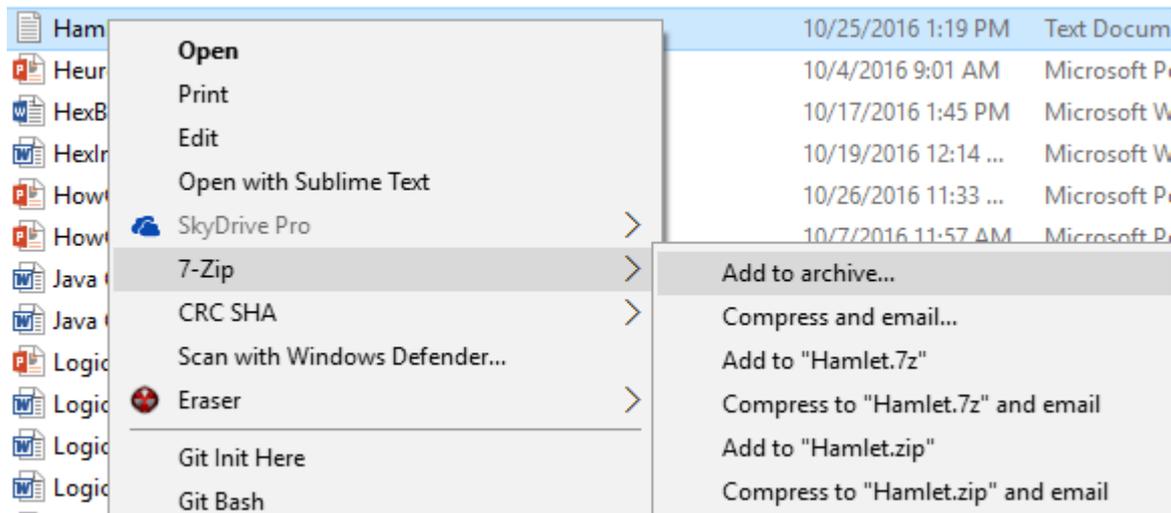
Text Compression Tool

If you have not already done so, open up the Text Compression Tool in Code Studio and watch the video explaining how to use it. Then choose one poem and build a simple dictionary using the table below.

Poem Name:

To Compress a File

Right click on the file and choose *7-Zip | Add to archive.*



To Compress a File

- Choose zip for Archive Format. →
- Click OK.

Add to Archive

Archive: I:\apcsp\
Hamlet.zip

Archive format: zip

Update mode: Add and replace files

Compression level: Normal

Path mode: Relative pathnames

Compression method: Deflate

Options

Create SFX archive

Compress shared files

Delete files after compression

Encryption

Enter password:

Reenter password:

Show Password

Encryption method: ZipCrypto

Number of CPU threads: 4 / 4

Memory usage for Compressing: 131 MB

Memory usage for Decompressing: 2 MB

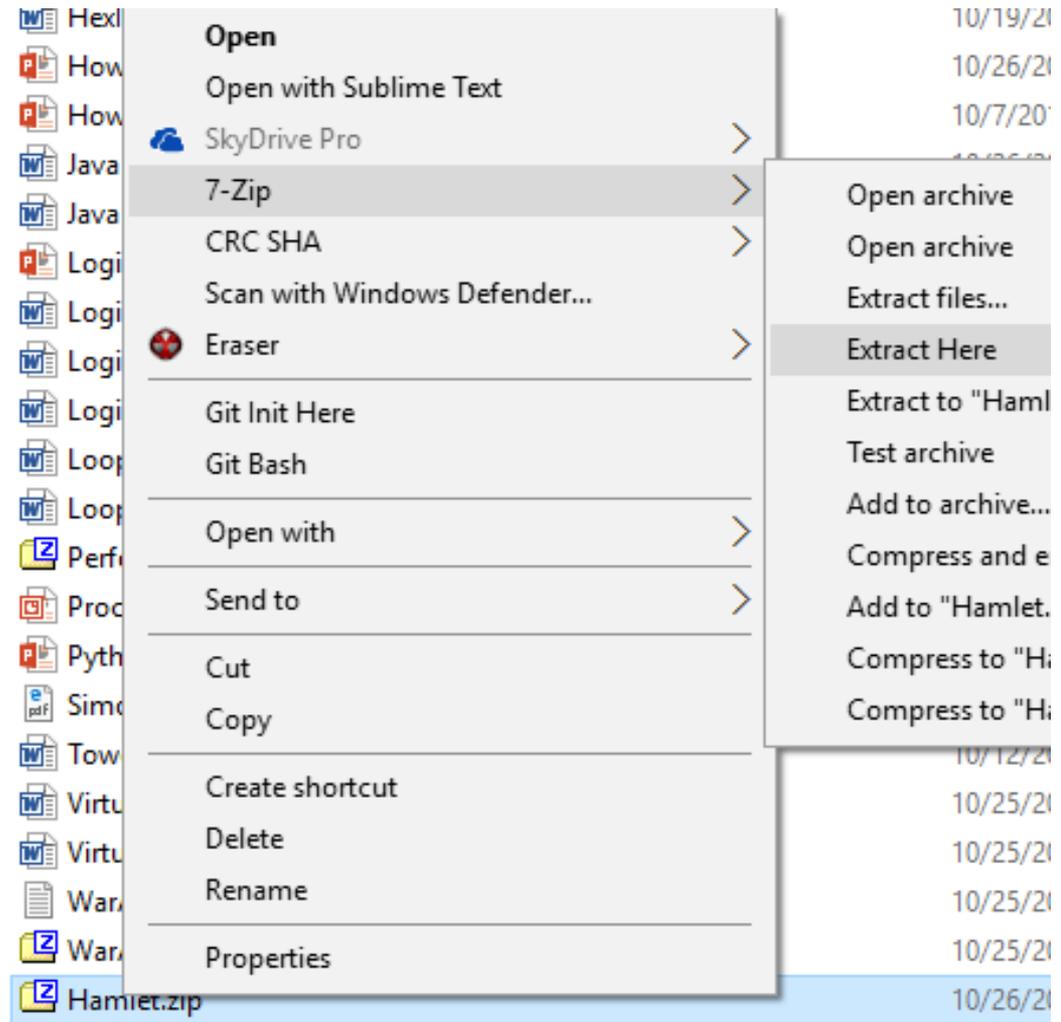
Split to volumes, bytes:

Parameters:

OK Cancel Help

To Decompress a File

Right click on the file and choose 7-zip | *Extract Here.*



Zip Compression Lab

- Watch a [2 minute animation of zip compression](#).
- Type your answers and submit the completed worksheet.

.zip compression

AP Computer Science Principles

Name _____

Steps to complete this assignment

1. Download the plain text file of Shakespeare's Hamlet from school loop or <http://www.gutenberg.org/cache/epub/2265/pg2265.txt>
2. Open the file in HxD to verify that you can read the text.
3. Record the size of the plain text file in the table below

	<u>Hamlet.txt</u>	<u>OneHello.txt</u>	<u>LotsOfHellos.txt</u>
Size of plain text in KB			
Size of <u>zip</u> in KB			
Compression ratio			

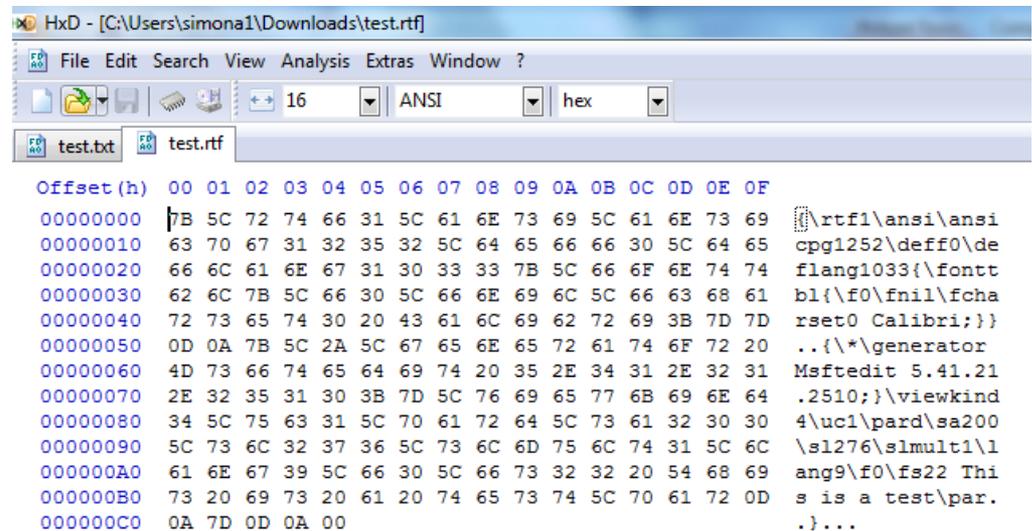
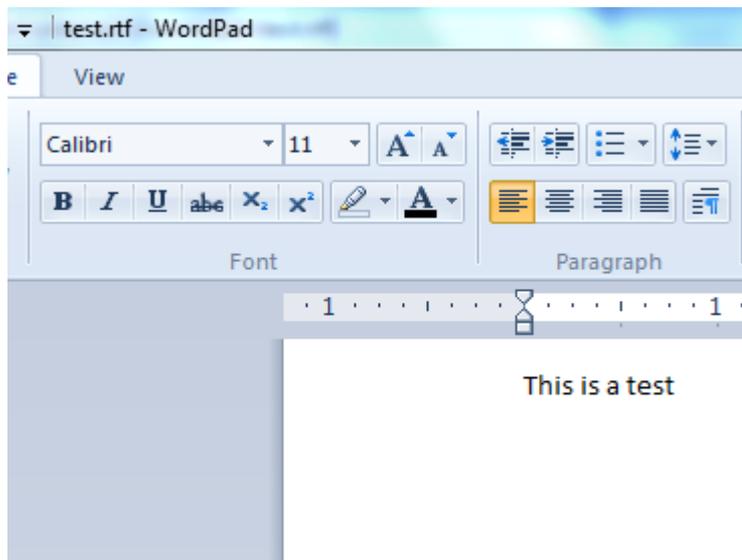
4. Compress the plain text file of Hamlet as a zip file. One way is to right click on the file and choose *7-Zip | Add to archive* and then choose *zip* as the *Archive format*
5. Record the size of the compressed zip file in the table above.
6. Calculate the compression ratio. The formula to calculate the compression ratio as a percentage is $100 \left(1 - \frac{z}{p} \right)$ where z is the size of the zip file and p is the size of the plain text file. Record the compression ratio in the table above.

File Carving

- File Carving is using a Hex Editor to edit the raw binary data.
- You can use a Hex editor to hide data inside of a file.

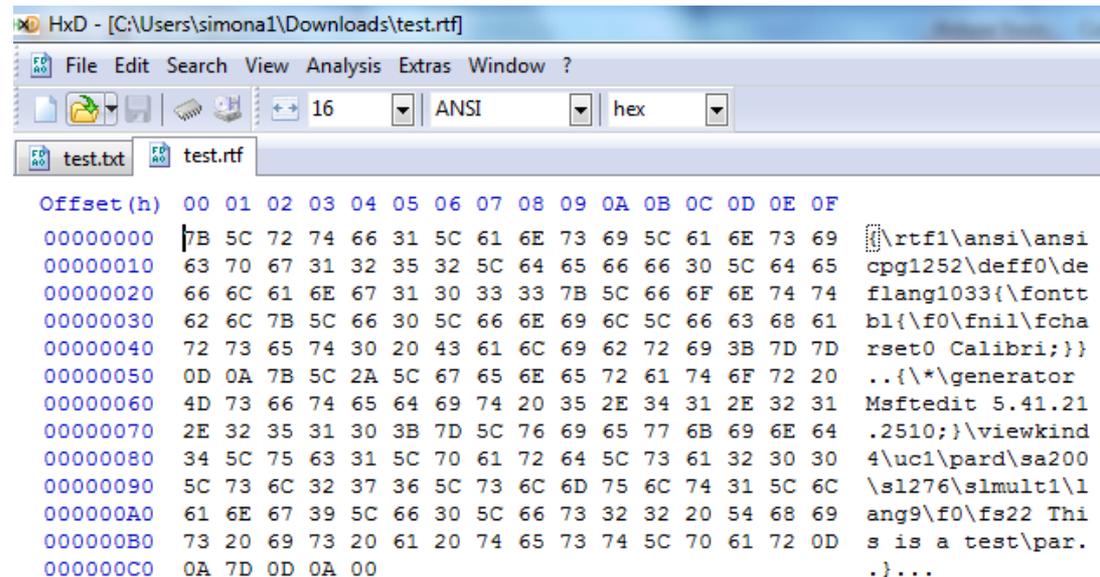
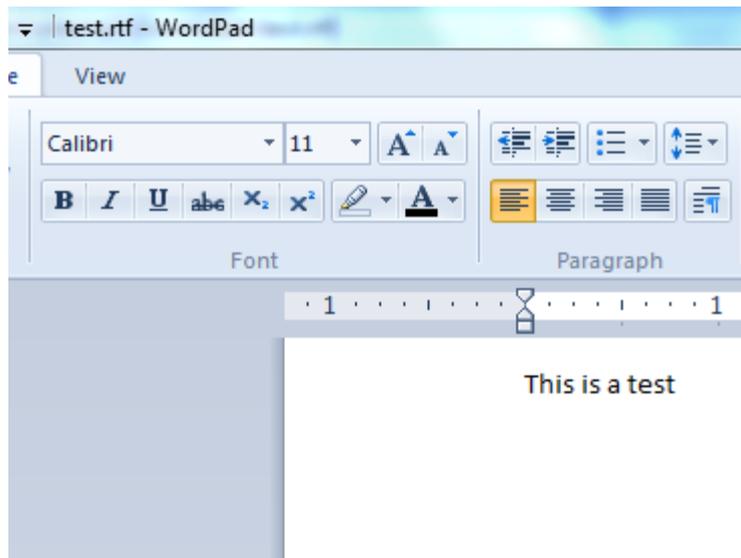
File Carving

- Let's say I create a new file in Word Pad.
- In addition to the text I've typed, there is other information I can see if I look at the file with HxD.



File Carving

- A rtf file always starts with **7B 5C 72 74 66**.
- **0A 7D 0D 0A 00** marks the end of the file.



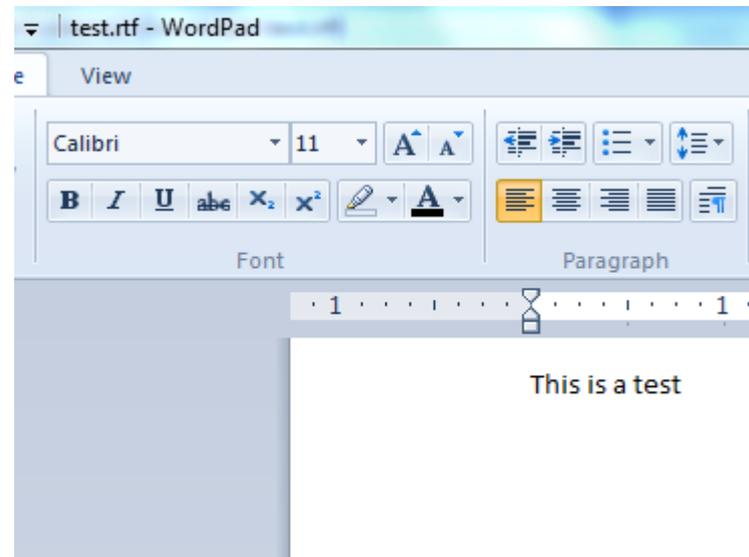
File Carving

- Wordpad will ignore any data after the end of file marker.
- I can hide data by copying and pasting it after the end of file marker.
- Here I've hidden a .jpg.

```
Offset(h) 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
00000000 7B 5C 72 74 66 31 5C 61 6E 73 69 5C 61 6E 73 69  [B]rtf1\ansi\ansi
00000010 63 70 67 31 32 35 32 5C 64 65 66 66 30 5C 64 65  cpfg1252\deff0\de
00000020 66 6C 61 6E 67 31 30 33 33 7B 5C 66 6F 6E 74 74  flang1033{\fontt
00000030 62 6C 7B 5C 66 30 5C 66 6E 69 6C 5C 66 63 68 61  bl{\f0\fnil\fcha
00000040 72 73 65 74 30 20 43 61 6C 69 62 72 69 3B 7D 7D  rset0 Calibri;}}
00000050 0D 0A 7B 5C 2A 5C 67 65 6E 65 72 61 74 6F 72 20  ..{\*\generator
00000060 4D 73 66 74 65 64 69 74 20 35 2E 34 31 2E 32 31  Msftedit 5.41.21
00000070 2E 32 35 31 30 3B 7D 5C 76 69 65 77 6B 69 6E 64  .2510;}\viewkind
00000080 34 5C 75 63 31 5C 70 61 72 64 5C 73 61 32 30 30  4\uc1\pard\sa200
00000090 5C 73 6C 32 37 36 5C 73 6C 6D 75 6C 74 31 5C 6C  \sl276\slmult1\l
000000A0 61 6E 67 39 5C 66 30 5C 66 73 32 32 20 54 68 69  ang9\f0\fs22 Thi
000000B0 73 20 69 73 20 61 20 74 65 73 74 5C 70 61 72 0E  s is a test\par.
000000C0 0A 7D 0D 0A 00 FF DB FF E0 00 10 4A 48 49 48 00  77...ÿÿà..JFIF.
000000D0 01 01 01 00 60 00 60 00 00 FF DB 00 43 00 02 02  .....ÿÿ.C...
000000E0 01 02 01 01 02 02 02 02 02 02 02 03 05 03 03  .....
000000F0 03 03 03 06 04 04 03 05 07 06 07 07 06 07 07  .....
00000100 08 09 0B 09 08 08 0A 08 07 07 0A 0D 0A 0A 0B 0C  .....
00000110 0C 0C 0C 07 09 0E 0F 0D 0C 0E 0B 0C 0C 0C FF DB  .....ÿÿ
00000120 00 43 01 02 02 02 03 03 03 06 03 03 06 0C 08 07  .C.....
00000130 08 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C  .....
00000140 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C  .....
00000150 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C 0C  .....
00000160 0C 0C 0C FF C0 00 11 08 00 5C 00 64 03 01 22 00  ...ÿÄ...\.d..".
00000170 02 11 01 03 11 01 FF C4 00 1F 00 00 01 05 01 01  .....ÿÄ.....
```

File Carving

- It still looks the same in Word Pad.
- The only way to discover the hidden data is to look through the raw binary data.
- Hacking competitions will often have challenges to find files secretly hidden inside of other files.



File Carving

- 3 secret files have been hidden in 3 different pictures
- Follow the instructions in the worksheet to find the secret files.
- Type or paste your answers on the worksheet, save it, and submit it.

Computer Forensics Lab Part 2

adapted from <http://dirbags.net/cff/tutorial/carving.html>

Background

In this lab you'll learn about File Carving. File Carving goes one step beyond reading raw binary data. In File Carving, you are editing and manipulating binary data as well. You are basically cutting and pasting one file inside of another in order to hide it.

Begin with the following image:



Encoding Images

- Today we're going to consider how you might use bits to encode a photographic image, or if you like: how could I encode vision?
- We're going to start simple, with black and white images.

Invent a B&W Encoding Scheme

Work through [this worksheet](#) in pairs

Unit 2 Lesson 3

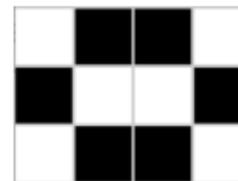
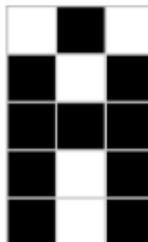
Name(s) _____ Period _____ Date _____

Activity Guide - Invent a B&W Encoding Scheme



Develop an Encoding Scheme

Look at the simple black-and-white images below. With your partner discuss how you might encode images like these in binary.



Record your ideas for your encoding in the space below. As you develop your encoding consider:

- What information will need to be included to reconstruct the image?
- How will that information be represented in binary?
- Try out your encoding with the sample images above. Is there any aspect of your encoding that is

Invent a B&W Encoding Scheme

- How have you encoded white and black portions of your image, what do 0 and 1 stand for in your encoding?
- Are your encodings flexible enough to accommodate images of any size? How do they accomplish this?
- Is your encoding intuitive and easy to use?
- Is your encoding efficient?

Pixels and Metadata

- Each little dot that makes up a picture is called a *pixel*.
- Where did this word pixel come from? It turns out that originally the dots were referred to as “picture elements”, and people think that got shortened to “pict-el” and eventually “pixel”.
- An image file must contain more than just a 0 or 1 for every pixel. It must contain other data that describes the pixel data.
- This is called *metadata*. In this case the metadata encodes the *width* and *height* of the image

Video

<https://www.youtube.com/watch?v=rJOa5Q5a1WM&feature=youtu.be>

☰ YouTube Search



Intro to Pixelation Encoding B & W

Code.org

C **O**
D **E**  160,630

1,654 views

B&W Pixelation Widget

Type your answers on this [worksheet](#) as you work with the [Code.org B&W pixelation widget](#).

Unit 2 Lesson 3

Name(s) _____ Period _____ Date _____

Activity Guide - B&W Pixelation Widget



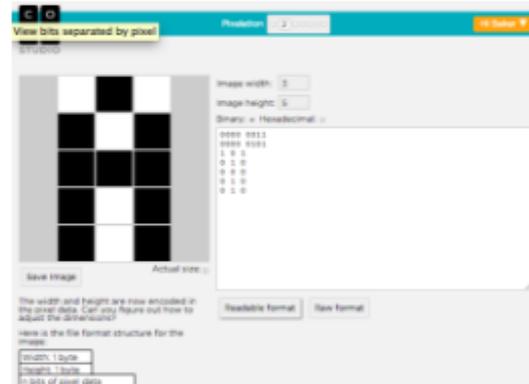
The B&W Pixelation Widget

The pixelation widget uses a file format as depicted below. For example, the 3x5 image of the letter “A,” shown at right within the Pixelation tool, would be encoded as a simple stream of these bits, organized like this (color added for emphasis):

000000110000010100000001101010000010010

We can break it up into pieces like so:

purpose	size	example
width	1 byte	0000 0011
height	1 byte	0000 0101
pixel data	varies	00000001101010000010010



B&W Image File Format

<i>metadata</i>	Bits 0-7 (1 byte) = width
	Bits 8-15 (1 byte) = height
<i>pixel data</i>	Bits 16 - n = pixel data
	0 = black (light off)
	1 = white (light on)

Metadata

- The image file protocol we used contains “metadata”: the width and height. Metadata is “**data about the data**” that might be required to encode or decode the bits.
- For example, you couldn’t render the B&W image properly without somehow including the dimensions.
- What other examples of metadata have we seen in the course so far?
- What other types of data might we want to send that would require metadata?

Music and Metadata

The screenshot displays the Mindwarp audio software interface. The window title is "Mindwarp" and it features standard window controls (minimize, maximize, close) in the top right corner. The menu bar includes File, Edit, View, Transport, Tracks, Generate, Effect, Analyze, and Help. The File menu is open, listing options such as New (Ctrl+N), Open... (Ctrl+O), Recent Files, Close (Ctrl+W), Save Project (Ctrl+S), Save Project As..., Save Compressed Copy of Project..., Check Dependencies..., Edit Metadata... (highlighted), Import, Export Audio... (Ctrl+Shift+E), Export Selected Audio..., Export Labels..., and Export Multiple... (Ctrl+Shift+L). The main workspace shows a multi-track audio editor with a timeline at the top marked from 45 to 2:15. The tracks contain blue audio waveforms. A control panel below the timeline includes a dropdown menu set to "Headphone (VIA HD Audio)", a volume slider, and various playback and processing icons. A "Click to Start Monitoring" button is visible in the top right of the track area.

Music and Metadata

<http://www.purple-planet.com/>

Edit Metadata Tags ×

Use arrow keys (or ENTER key after editing) to navigate fields.

Tag	Value
Artist Name	Purple Planet Music
Track Title	
Album Title	
Track Number	
Year	2016
Genre	Instrumental
Comments	© Purple Planet Music
Composer	Chris Martyn/Geoff Harvey
Software	Logic Pro 9.1.8

Add Remove Clear

Genres: Edit... Reset...

Template: Load... Save... Set Default

OK Cancel

Music and Metadata

HxD - [C:\Users\simona1\Downloads\Mindwarp.mp3]

File Edit Search View Analysis Extras Window ?

16 ANSI hex

Mindwarp.mp3

Offset (h)	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	
00000000	49	44	33	02	00	00	00	00	1F	76	54	53	53	00	00	10	ID3.....vTSS...
00000010	00	4C	6F	67	69	63	20	50	72	6F	20	39	2E	31	2E	38	.Logic Pro 9.1.8
00000020	43	4F	4D	00	00	68	00	65	6E	67	69	54	75	6E	4E	4F	COM..h.engiTunNO
00000030	52	4D	00	20	30	30	30	30	31	36	43	36	20	30	30	30	RM. 000016C6 000
00000040	30	31	32	39	32	20	30	30	30	30	41	35	32	43	20	30	01292 0000A52C 0
00000050	30	30	30	45	30	39	33	20	30	30	30	31	43	38	31	46	000E093 0001C81F
00000060	20	30	30	30	31	35	33	45	35	20	30	30	30	30	38	38	000153E5 000088
00000070	41	32	20	30	30	30	30	38	37	45	46	20	30	30	30	31	A2 000087EF 0001
00000080	38	35	34	39	20	30	30	30	31	37	44	33	39	00	43	4F	8549 00017D39.CO
00000090	4D	00	00	82	00	65	6E	67	69	54	75	6E	53	4D	50	42	M...engiTunSMPB
000000A0	00	20	30	30	30	30	30	30	30	20	30	30	30	30	30	30	. 00000000 00000
000000B0	32	31	30	20	30	30	30	30	30	41	46	42	20	30	30	30	210 00000AFB 000
000000C0	30	30	30	30	30	30	30	35	43	35	42	37	35	20	30	30	00000005C5B75 00
000000D0	30	30	30	30	30	30	20	30	30	33	42	43	30	41	32	20	000000 003BC0A2
000000E0	30	30	30	30	30	30	30	30	20	30	30	30	30	30	30	30	00000000 00000000
000000F0	30	20	30	30	30	30	30	30	30	20	30	30	30	30	30	30	0 00000000 000000
00000100	30	30	30	20	30	30	30	30	30	30	30	20	30	30	30	30	000 00000000 0000
00000110	30	30	30	30	30	00	54	50	31	00	00	15	00	50	75	72	00000.TP1....Pur
00000120	70	6C	65	20	50	6C	61	6E	65	74	20	4D	75	73	69	63	ple Planet Music
00000130	00	54	43	4D	00	00	1B	00	43	68	72	69	73	20	4D	61	.TCM....Chris Ma
00000140	72	74	79	6E	2F	47	65	6F	66	66	20	48	61	72	76	65	rtyn/Geoff Harve
00000150	79	00	54	59	45	00	00	06	00	32	30	31	36	00	54	43	y.TYE....2016.TC
00000160	4F	00	00	06	00	28	33	33	29	00	43	4F	4D	00	00	36	O....(33).COM..6
00000170	01	65	6E	67	FF	FE	00	00	FF	FE	A9	00	A0	00	50	00	.engÿb...ÿb@. .P.
00000180	75	00	72	00	70	00	6C	00	65	00	20	00	50	00	6C	00	u.r.p.l.e. .P.l.
00000190	61	00	6E	00	65	00	74	00	20	00	4D	00	75	00	73	00	a.n.e.t. .M.u.s.
000001A0	69	00	63	00	00	00	54	53	50	00	00	15	00	50	75	72	i.c...TSP....Pur
000001B0	70	6C	65	20	50	6C	61	6E	65	74	20	4D	75	73	69	63	ple Planet Music
000001C0	00	54	53	43	00	00	1B	00	43	68	72	69	73	20	4D	61	.TSC....Chris Ma
000001D0	72	74	79	6E	2F	47	65	6F	66	66	20	48	61	72	76	65	rtyn/Geoff Harve
000001E0	79	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	y.....
000001F0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00002000	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00002100	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

Try the NPR Listening Test

<http://www.npr.org/sections/therecord/2015/06/02/411473508/how-well-can-you-hear-audio-quality>

STREAMING AT THE TIPPING POINT

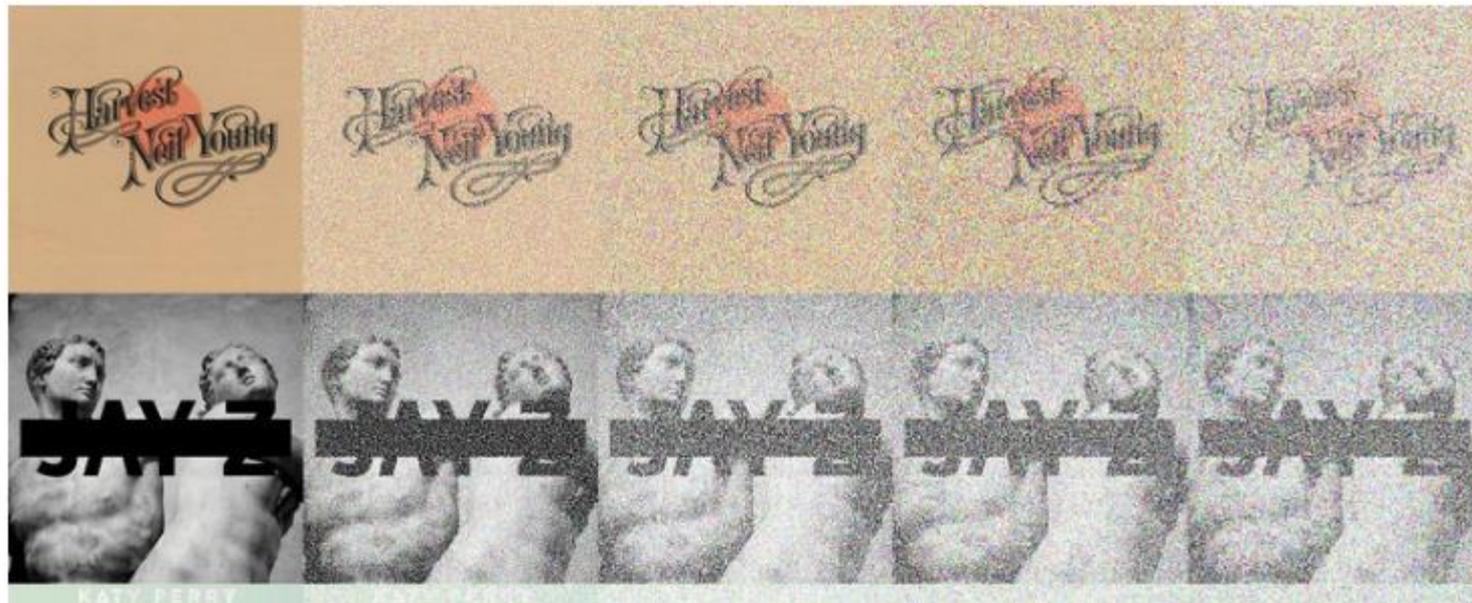
How Well Can You Hear Audio Quality?

June 2, 2015 - 2:10 PM ET

TYLER FISHER

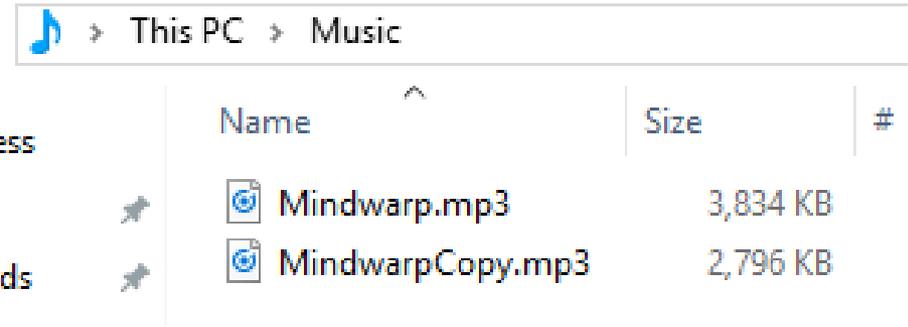


JACOB GANZ



Practice Quiz

Question:



	Name	Size	#
ess	Mindwarp.mp3	3,834 KB	
ds	MindwarpCopy.mp3	2,796 KB	

A Student has two music files of the same song. The second file was copied from the first and has the same length. Which of the following statements about the files is NOT true? (choose one)

- A. The copy was saved in a format that uses more bits per second than the original song.
- B. The copy was saved using a lossy compression technique.
- C. The original song was saved using a lossy compression technique.
- D. The copy was saved in a format that uses less bits per second than the original song.

Practice Quiz Question

A ride sharing service allows users to request a car using a program on their cell phone. The program sends data about the location of the person requesting the ride, the time of the request and the location the person wants to travel to. In addition to the data, the program sends the following metadata:

- The username of the user requesting the ride.
- The password of the user requesting the ride.

For which of the following goals would it be more useful to analyze the metadata instead of the data?

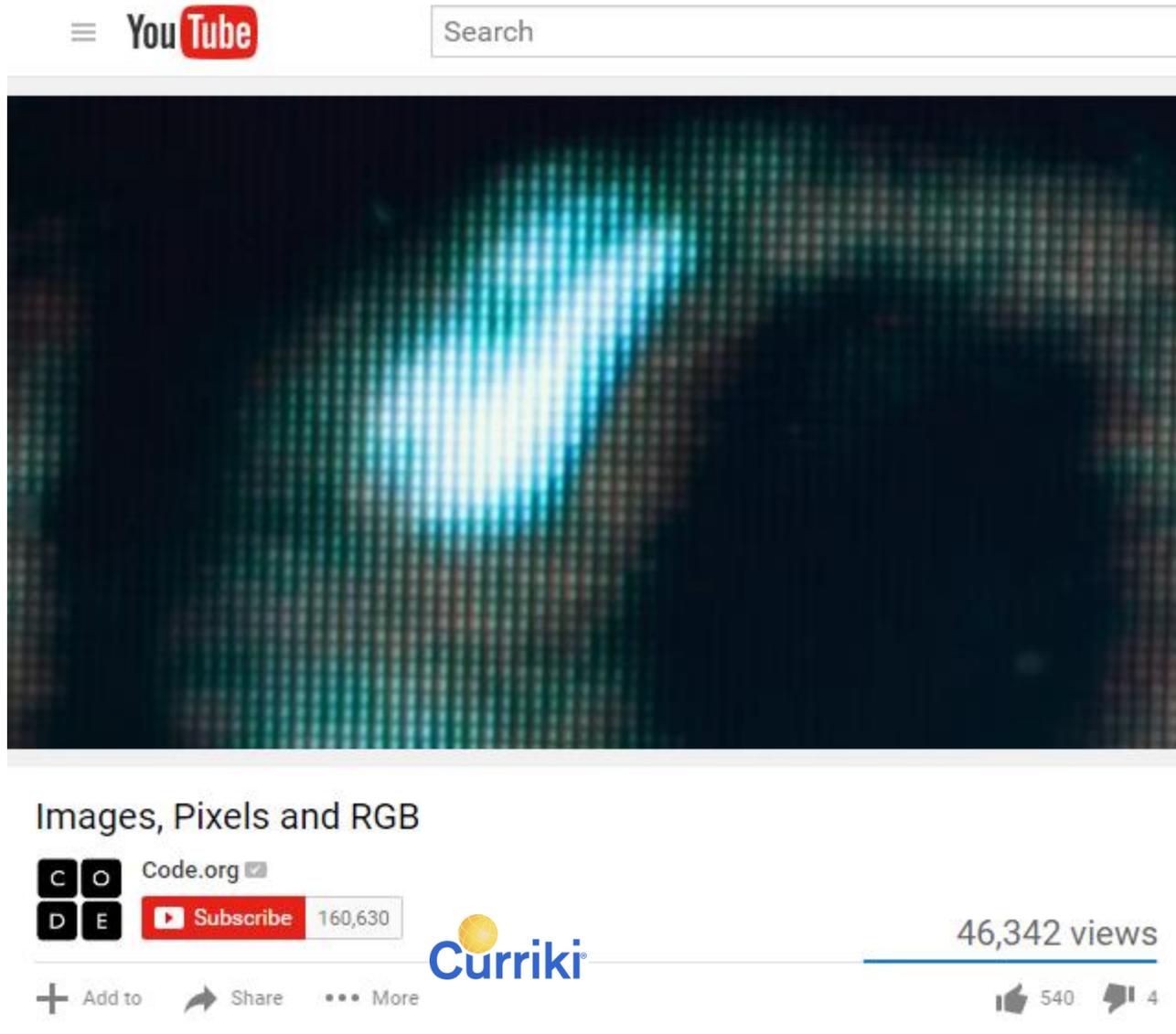
- A. To determine the users who request the most rides.
- B. To determine the time of day that users request the most rides.
- C. To determine the most popular destinations.
- D. To determine the locations with the most requests for rides.

Color

- In the previous lesson we came up with a simple encoding scheme for B&W images. What if we wanted to have color?
- How would you represent color for each pixel?
- How many different colors could you represent?

Video

<https://www.youtube.com/watch?v=15aqFQQVBWU&feature=youtu.be>



The image shows a YouTube video player interface. At the top left is the YouTube logo with a menu icon. To its right is a search bar containing the text "Search". The video player area displays a blurred image of a person's face, likely the presenter, with a blue and green color scheme. Below the video player, the title "Images, Pixels and RGB" is shown. Under the title is the channel name "Code.org" with a verified badge. To the right of the channel name is a red "Subscribe" button and the number "160,630". Below the channel information is the Curriki logo. To the right of the Curriki logo is the view count "46,342 views". At the bottom left are icons for "Add to", "Share", and "More". At the bottom right are icons for "Like" (540) and "Comment" (4).

YouTube

Search

Images, Pixels and RGB

Code.org

Subscribe 160,630

Curriki

46,342 views

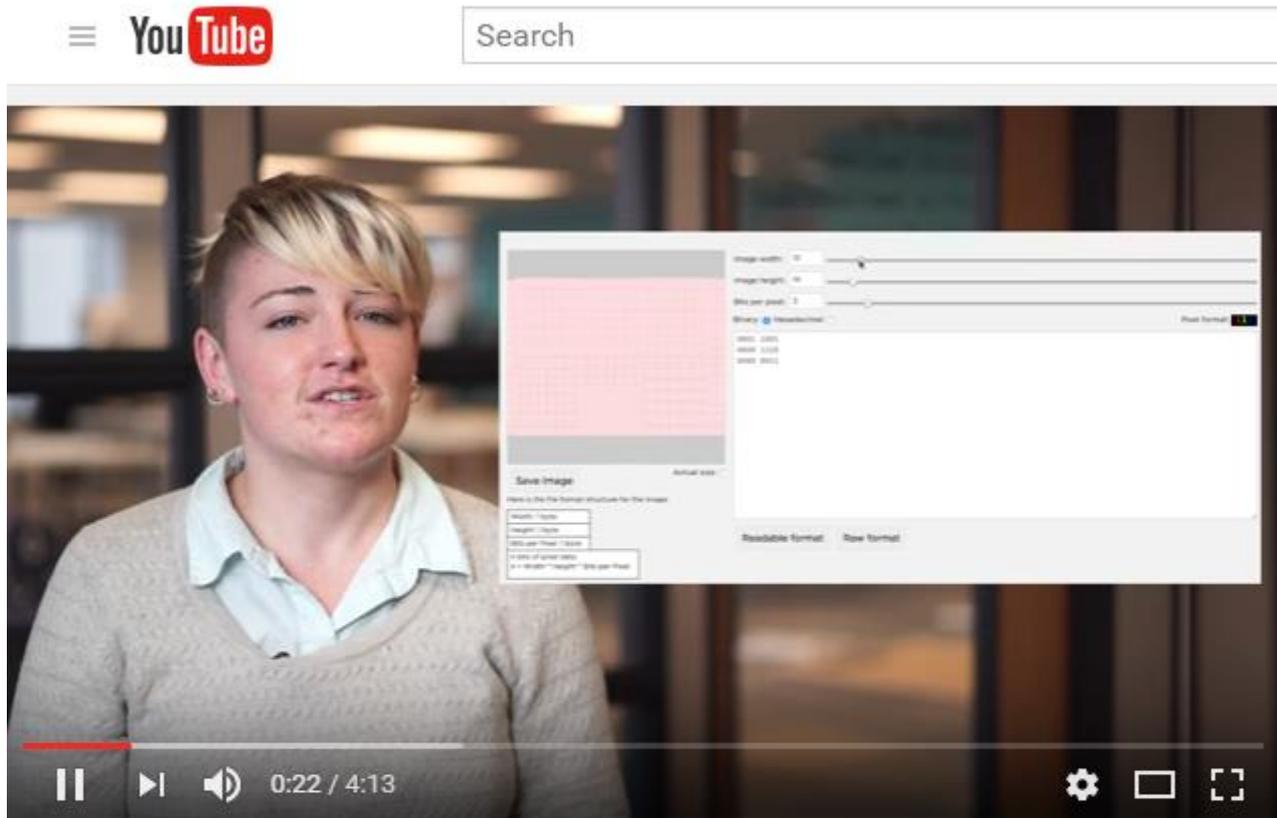
Add to Share More Like 540 Comment 4

Images, Bits and RGB.

- Image sharing services are a universal and powerful way of communicating all over the world.
- Digital images are just data (lots of data) composed of layers of abstraction: pixels, RGB, binary.
- The RGB color scheme is composed of red, green, and blue components that have a range of intensities from 0 to 255.
- Screen resolution is the number of pixels and how they are arranged vertically and horizontally, and density is the number of pixels per a given area.
- Digital photo filters are not magic! Math is applied to RGB values to create new ones.

Video

https://www.youtube.com/watch?v=763E3_Z6Hng&feature=youtu.be



CS Principles: Intro to the Color Pixelation Widget - Part 1



Code.org 

 **Subscribe** 160,630

1,308 views

Encoding Color Images

Type your answers on this [worksheet](#) as you work with the [Code.org Color pixelation widget](#).

Unit 2 Lesson 4

Name(s) _____ Period _____ Date _____

Activity Guide - Encoding Color Images



Objectives:

- Practice with the color pixelation tool.
- Use the Pixelation Widget to recreate specific colors.
- Recreate simple color images and describe the difference when using 6 or 12 bits per pixel.
- Encode colors with hex.

Directions:

Go to Code Studio - Find this lesson on Code Studio

The tasks below follow the guided sequence in Code Studio which has tutorial videos followed by specific tasks. The purpose of this activity is only to become familiar with the color pixelation tool, and to practice a little bit, in order to be comfortable enough to start the **favicon assignment**.

Step 1: 3-bit color

Tutorial Video: How to use the pixelation widget to control color.

Task 1: Fill in the last two pixels with the missing colors

Problem: fill in the last two pixels.

m... he pixel data so that the blue and yellow pixels



Video

<https://www.youtube.com/watch?v=xK9z51Tin4E&feature=youtu.be>

The screenshot shows the YouTube Color Pixelation widget interface. At the top, there is a search bar and the YouTube logo. Below the search bar, the widget title "Color Pixelation" is displayed with a "Sign in" button. The main interface includes a "STUDIO" section with a grid of color swatches (C, O, D, E) and a large gray area for the image. To the right of the image area are sliders for "Image width", "Image height", and "Bits per pixel", and radio buttons for "Binary" and "Hexadecimal" (selected). Below these are "Readable format" and "Raw format" buttons. A text area contains the letter "I". At the bottom left, there is a "Save Image" button and a table showing the file format structure for the image.

Width: 1 byte
Height: 1 byte
Bits per Pixel: 1 byte
n bits of pixel data
n = Width * Height * Bits per Pixel

CS Principles: Intro to the Color Pixelation Widget - Part 2

 Code.org
 **Subscribe** 160,630

970 views

Video

<https://www.youtube.com/watch?v=Xhqz3ffGm74&feature=youtu.be>

Image width: 4
Image height: 4
Bits per pixel: 12
Binary: Hexadecimal: Pixel format:

```
04  
04  
0c  
00 00
```

Readable format Raw format

Save Image Actual size:

Here is the file format structure for the image:

Width: 1 byte
Height: 1 byte
Bits per Pixel: 1 byte
n bits of pixel data
n = Width * Height * Bits per Pixel

CS Principles: Intro to the Color Pixelation Widget - Part 3



Code.org

160,635

880 views

Add to Share More

1 0

Personal Favicon Project

https://docs.google.com/document/d/1bUVXHZUafmxDT5pOGIWSFkQSc_0LI_lzMtfSh8Jii20/edit

Unit 2 Lesson 4

Name(s) _____ Period _____ Date _____

Activity Guide - Personal Favicon Project



Objectives

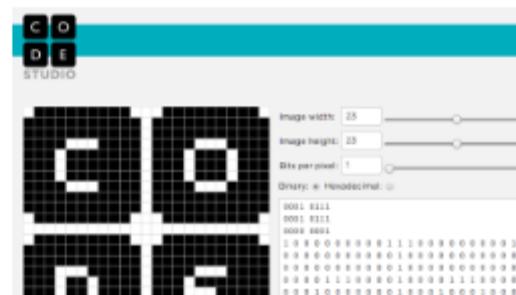
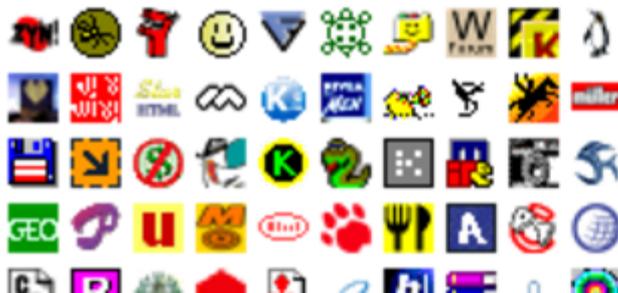
- Encode a 16 x 16 pixel image with at least 12 bits per pixel.
- Create and encode a color image of your own design.
- Explain the benefits of using hexadecimal numbers for representing long streams of bits.

Overview

A favicon is a small image, usually 16x16 pixels, that is typically shown in a web browser's address bar next to the title of the page or web address for a particular site. It is typically a small version of a company logo or some other symbol for the site. A favicon for Code.org is shown to the right.



Favicons are designed by artists and programmed into web pages by web designers. Below are some examples of favicons—you might recognize some!

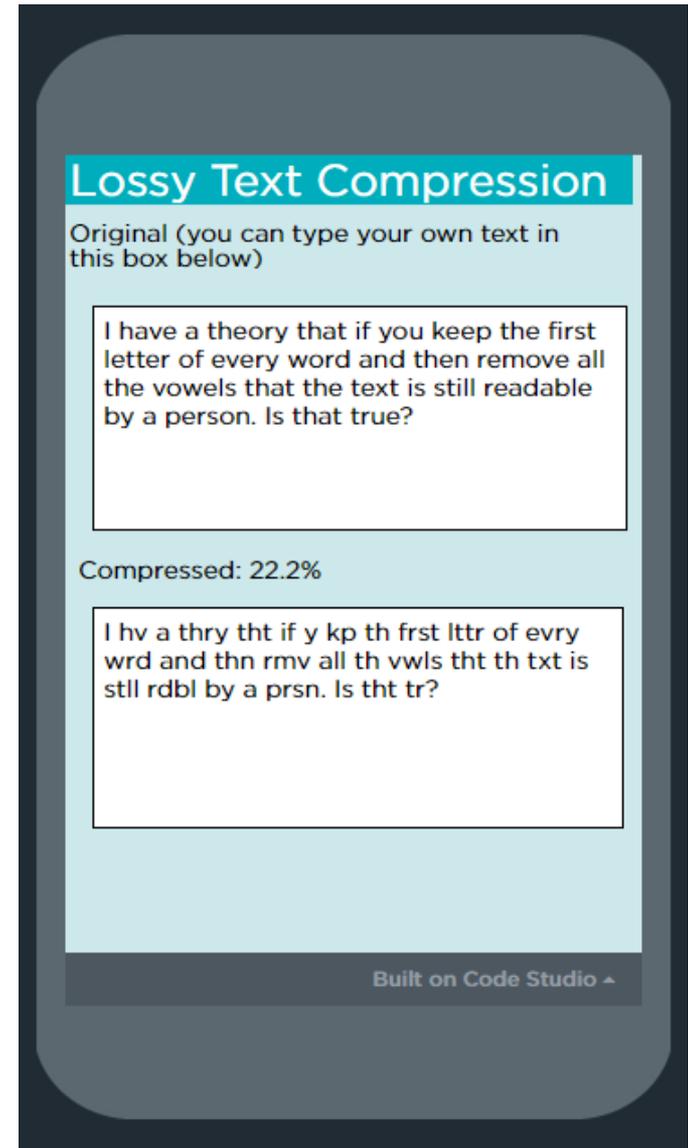


Practice Quiz Questions

1. How many bits (or bytes) are required to encode an image that is 25 pixels wide and 50 pixels tall, if you encode it with 24 bits per pixel?
2. Imagine that you have an image that is too dark or too bright. Describe how you would alter the RGB settings to brighten or darken it. Give an example.

Lossy Text Compression App

- With a partner, go to the [Lossy Text Compression App - App Lab](#).
- Discuss the following questions:
 - What is happening in the app?
 - Should this “count” as text compression? Why or why not?
 - What do you think “lossy” refers to?



File Formats Rapid Research

- Pick a partner and choose one file format fill in **one row** of the table.
- It's OK if two groups research the same type.
- We'll fill in the complete table in class.

Name(s) _____ Period _____ Date _____

Worksheet - File Formats Rapid Research



Rapid Research

You and a partner will do some rapid research and reporting on some of the most common file formats that are out there. Your teacher will assign you one or more of the file formats listed below. Use the web as your research tool.

Fill in the row of the table for the format you were assigned. TIPS:

- When you visit a web page do a text search on the page for "compress"
- In most browsers the keystroke Ctrl+F (Windows) or ⌘+F (Mac) will get you there.

File format name	What type of information or data is it?	Compression? uncompressed, lossy, lossless	How does it work? (just a few brief words about the theory behind the encoding or compression)
BMP (bitmap)			
JPEG (or JPG)			
WAV			
PNG			
MP3			

File format name	What type of information or data is it?	Compression?	If compressed, lossy or lossless?
BMP (bitmap)			
JPEG (or JPG)			
WAV			
PNG			
MP3			
GIF			
ZIP			

Can you match the encoding type with the data type and compression?

<https://studio.code.org/s/csp2/stage/5/puzzle/2>

BMP	?	Compressed Image - Lossy
WAV	?	Uncompressed Image
JPEG	?	Compressed Files - Lossless
GIF	?	Uncompressed Sound
MP3	?	Compressed Image - Lossless
ZIP	?	Compressed Sound - Lossy
PNG	?	Compressed Image - Lossless (256 color limit)