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Building Your Own Custom Computer

Prepared for:

Professor Michael Saad

CMNS 113 section 1

This provides:

Safe procedures for assembling a computer

A buying guide to help the user make informed decisions on their purchases

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# Acronym list by order of appearance

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| ESD | Electro static discharge can occur when an object has too much built up static electricity. This can be harmful to computer parts |
| PC | Personal Computer |
| I/O Shield | Input/Output shield. |
| CPU | Central Processing Unit. The brain of the computer |
| RAM | Random Access Memory. The short term memory/storage of the computer |
| CD | Compact Disk. Commonly used external storage |
| HDD | Hard Disk Drive. Stores all of the computers data |
| SSD | Solid State Drive. A more effective but more expensive version of the HDD |
| PCI | Peripheral Component Interconnect. Slots on the motherboard that allow you to install extra components to your computer |
| GPU | Graphical Processing Unit. Component that allows for good looking graphics |
| SLI | Scalable Link Interface. System that allows multiple identical GPU's to work off each other for greater efficiency. Crossfire is an identical system to this. |
| NVidia/AMD | Dominant companies that design computer components |
| USB | Universal Service Board. A connector that can be used for a range of devices |
| SATA | Serial Advanced Technology Attachment. The current standard for connecting HDD's to Motherboards |
| HDMI/DVI/VGA | Video transmission standards |
| POST | Power on self test |

# Important Symbols

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*A useful tip for building your PC*

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*A warning about potential harm to components*

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*A warning about extra potential for ESD*

# Introduction:

In this guide we will be describing how to safely assemble an average PC. It will not cover any advanced subjects or software related topics. The Instructions are simple enough that any layman will be able to follow along provided that they can work simple tools and handle parts gently.

But why would you want to go through the trouble of building your own computer when it is so much easier to buy one pre-built? The clearest answer to this is quality. You know exactly what went into your computer and how much it was worth. Computer manufacturers may assemble from a number of parts with wildly varying quality. You might also save money since you are not paying for assembly or parts you don't need. In the future if you feel the need to upgrade you will be able to do it much more easily as manufactured computers may be difficult to manually upgrade.

We hope this manual helps you to create an efficient and powerful personal computer

# Tools required:

* A magnetic tipped philips screwdriver that is at least 6" long
* An anti static wristband(See figure 1.1)
* Many zip ties for wire management
* A small wire cutter for cutting zip ties

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*Many computer parts vary across manufacturers. If there are any inconsistencies please refer to the products manual.*

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*The anti static wrist band should be worn during every step to minimize risk of damaging your parts.*

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***DANGER:*** *The computer should never be connected to power while you are handling the parts inside. You may be fatally electrocuted.*

# 1. Prepare the Workstation

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| C:\Users\Clay\Dropbox\CMNS manual project assets\Anti static wrist strap.jpg  Figure 1.1: Anti Static Wrist Band |

1.1 Clear a table to do the computer assembly. The table should be clean and free of dust. Preferably have the table set up away from carpeted floors, but if that cannot be helped, be sure to have an anti-static wristband.

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*Computer components are sensitive to electro static discharge (ESD). To prevent damage to these parts, an anti-static wristband should always be used when building or repairing computers. Attach the wrist band snuggly around your wrist, and clamp the end of the wire on to any unpainted metal surface, like the inside of the computer case. If you do not have access to an anti-static wristband, ground yourself by touching an unpainted metal surface, such as a door knob, every few minutes, although this is not ideal.*

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*it is important to schedule yourself enough time to complete the computer build. First time builders should set aside 3-4 hours for the process.*

# 2. Prepare the Case

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| C:\Users\Clay\Dropbox\CMNS manual project assets\Avergage case.jpg  Figure 2.1: Average Empty Case |

2.1 Remove the case you will be using from the box, and remove any plastic bags or packing foam it was packaged in.

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| C:\Users\Clay\Dropbox\CMNS manual project assets\f4-01.jpg  Figure 2.2: Thumb Screw |

2.2 Remove the case's side panels. The panels are generally attached by 2 thumb screws at the back of the case, but some do require the use of a Philips screwdriver.

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*Some cases will also have a locking mechanism that must be depressed to release the panels from the case. Refer to the manual that came with the case if you have any problems.*

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| C:\Users\Clay\Dropbox\CMNS manual project assets\standoff2.jpgFigure 2.3: Motherboard Stand-offs |

2.3 Install the standoffs in the case by gently screwing them into the holes provided in the bottom of the case.

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*Only twist until they are secure, as over tightening will strip the threading and make removal difficult should you ever need to.*

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*Stand-offs need to be placed to specifically accommodate a motherboard. See Figure 3.2*

2.4 Many cases have removable hard drive racks, along with built in racks.*(Seen in drives section)* If you can mount the hard drives you plan to install in the built in racks without needing the removable racks, it is generally advisable to remove the extra racks. Doing so will grant you more room to work in the case, and will also increase air flow for cooling. Once you have finished this step, set the case aside.

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| C:\Users\Clay\Dropbox\CMNS manual project assets\IO shield.jpg  Figure 2.4: I/O Cover With Corresponding Motherboard Components |

2.5 All cases and motherboards come with an I/O cover or shield. Choose the one that matches the motherboard and Insert it into the rectangular slot that fits it on the case. Should you need to remove the cover for any reason simply push on it until it pops back out.

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*I/O Covers have metal prongs that may obstruct placement of motherboard ports. Feel free to bend these to make room. But do not remove them as they ground the ports to the case*

# 3. Prepare the Motherboard

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| C:\Users\Clay\Dropbox\CMNS manual project assets\Motherboard.png  Figure 3.1: Motherboard |

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| ***C:\Users\Clay\Dropbox\CMNS manual project assets\case-locations.jpg***  Figure 3.2: Motherboard standoff locations |

3.1 Remove the motherboard and bag from the cardboard box. Next, remove the motherboard from the anti-static bag. Be careful to only hold the motherboard from the bottom (flat side) and side edges, as many of the components, such as transistors, are susceptible to bending. Finally, set the motherboard on the cardboard box, with the bottom of the motherboard against the box.

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*Do not set the motherboard down on the antistatic bag it came in. The antistatic properties are only on the inside of the bag, and having the motherboard come in contact with the outside of the bag puts it at risk of ESD.*

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*Do not place the motherboard into the case yet as it will make the following steps harder. Instead leave it on the cardboard.*

# 4. Install the CPU

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| ***C:\Users\Clay\Dropbox\CMNS manual project assets\DT_Haswell_i7_FB_678x452.jpg***  Figure 4.1: CPU |

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| C:\Users\Clay\Dropbox\CMNS manual project assets\CPU latch.jpg  Figure 4.2: CPU Socket and Latch   * Open latch and remove plastic insert * Check orientation of CPU * Insert CPU * Close latch |

4.1 Remove the CPU and CPU cooler from their box. Next, remove the plastic protector from the CPU socket on your motherboard. To do this, press gently down and out on the torsion arm until it swings free. As the torsion arm is raised, it will open the metal brackets that will secure the CPU into place. Remove the plastic insert. The brackets on the socket should now be open and ready to accept the CPU.

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*Take note of the plastic extensions on the motherboard socket. These will line up with notches on the CPU ensuring the unit drops in safely.* ***Do not force the CPU***

4.2 Carefully remove the CPU from its plastic package. CPUs will have either pins or solder bumps on the side that mates with the socket on the motherboard *(See Figure 4.1).* The pins are very fragile so avoid contact with them. Hold the CPU only on the edges, as touching the smooth top side could leave oil from your skin that will have to be removed before the cooling unit is attached. Holding the CPU horizontally level 1/4'' above the socket, and lining up the notches in the CPU with the extensions in the socket, gently lower the CPU until notches fit over the extensions, and then drop the CPU into the socket. The unit should now be sitting square and flat in the socket. Close the torsion arm, and lock into place. It is common for the torsion arm to require some light force when closing, and there may be a sound as the CPU is mated with the socket.

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# 5. Install the CPU cooler

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| C:\Users\Clay\Dropbox\CMNS manual project assets\Heatsink.jpg  Figure 5.1: Standard CPU Heat Sink |

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| C:\Users\Clay\Dropbox\CMNS manual project assets\ex-blc-369.jpg  Figure 5.2: Example Liquid Cooler |

5.1 Remove the plastic film that covers the pre-applied thermal paste of the heatsink, being cautious to avoid contact with the paste. If the heatsink does not have thermal paste already applied, some will have to be installed. For this, refer to step 5.2b.

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5.1b Only do this step if your heatsink DOES NOT have thermal paste pre-applied, you will see a plastic film over the metal connecter if there is thermal paste. If there is no thermal paste then squeeze a pea-sized amount of thermal paste onto the middle of the CPU. Using a business card (or latex gloves and your finger) spread the thermal paste outwards until it is covering the entire surface of the CPU. If any thermal paste gets onto the motherboard, wipe it up with a paper towel.

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| C:\Users\Clay\Dropbox\CMNS manual project assets\Heatsink installation.jpg  Figure 5.3: Heat Sink Installation   * Gently place heat sink on top of CPU * Press the pegs into the guide holes * Connect fan power connector to nearby socket on motherboard |

5.2 Align the CPU cooler assembly so the posts on the bottom of the fan align with the 4 holes around the CPU in the motherboard. The cooler assembly should be rotated so that the power plug reaches the CPU fan power socket on the motherboard. The power socket will be labeled on the motherboard for easy identification. Lower the cooler assembly onto the CPU and lightly press the pegs into the guide holes and let go of the assembly. Press the buttons on the top of each of the assembly pegs until they thread through the guide holes and lock into place. Finally, attach the power cable to the CPU cooler power socket on the motherboard.

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It is important to not remove the cooler assembly at this point, as doing so will damage the integrity of the thermal paste.

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*If thermal paste must be reapplyed. clean the top of the CPU using a cotton swab damp with Isopropyl alcohol by gently scrubbing only the smooth exposed area of the CPU. The CPU should now be clean and dry.*

# 6. Install the Motherboard in the Case

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| C:\Users\Clay\Dropbox\CMNS manual project assets\IO_Shield_wiki.jpg  Figure 6.1: I/O Cover |

6.1 Place the case flat on the table with the open side up. Take note of where the I/O hookups are on the motherboard, as they will have to be dropped in a threaded through the I/O cover (See figure 6.1) installed in the case. Lower the motherboard into the case, I/O side first until the motherboard is lying flat in the case(See Figure 6.2). The motherboard should only be held on the sides, but now you can also hold the cooler assembly(See chapter 5) for extra control. Once placed in the case, the standoffs that were installed earlier should line up with the holes along that are noted on the motherboard*(See Figure 3.2)*. It is important that only the circled holes come in contact with the standoffs as those areas are insulated, and won’t conduct electric current.

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| C:\Users\Clay\Dropbox\CMNS manual project assets\Placing into IO.jpg  Figure 6.2: Insertion Technique   * Lower motherboard into case * Insert ports through the I/O cover * Secure to stand-offs |

6.2 With a Philips screwdriver, secure the motherboard to the stand-offs with the screws that were provided with your case.

# 7. Install RAM to the Motherboard

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| C:\Users\Clay\Dropbox\CMNS manual project assets\RAM stick diagram.PNG  Figure 7.1: RAM Chip With Notch |

7.1 Remove the RAM sticks from their packaging, taking note of the notches. RAM sticks are keyed as to prevent improper installation, and can only be inserted one way. Pressing firmly and evenly, press the RAM sticks into the socket until the locking posts engage.

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*You may need to remove the RAM in the future to replace a broken chip or to upgrade. If you need to do this simply press on the white tabs securing the chip in place and the chip will slide out.*

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| C:\Users\Clay\Dropbox\CMNS manual project assets\RAM slots picture adjusted.png  Figure 7.2: RAM Sockets |

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*RAM can be installed in either single or dual channel. Most of the time, the RAM sockets will be color coded. If installing 2 sticks of RAM, install them into the same color socket. If the sockets are not color coded, refer to the motherboard manual for proper installation. See Figure 7.2*

# 8. Install Drives

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| C:\Users\Clay\Dropbox\CMNS manual project assets\CD drive.jpg  Figure 8.1: ***5.25'' CD*** drive |

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| C:\Users\Clay\Dropbox\CMNS manual project assets\Hard drive.jpg  Figure 8.2: Hard Drive |

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| C:\Users\Clay\Dropbox\CMNS manual project assets\Computer faceplate.png  Figure 8.3: ***5.25'' CD Drive Bays*** |

8.1 Remove the cover on the 5.25'' CD drive bay and slide your CD drive into the bay with the SATA/Power connectors facing into the case until the holes in the bay line up with the holes in the drive. Secure the drive in place with the provided screws.

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| C:\Users\Clay\Dropbox\CMNS manual project assets\Hard drive racks.jpg  Figure 8.4: HDD Racks |

8.2 Install HDDs into the smaller 3.5'' bays by sliding them in from the back of the mounting rack until the holes line up, and secure them with the provided screws. Smaller SSDs can also be installed in these bays, but will use the screw holes on the bottom side of the drive bay.

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*Your HDD may come with rubber washers to prevent vibration when installed in the case. Install these according to the drives manual before you slide the drive into the bay.*

# 9. Install Power Supply

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| C:\Users\Clay\Dropbox\CMNS manual project assets\Power Supply.jpg  Figure 9.1: Power Supply Unit |

9.1 Power supplies can either be installed on the bottom-rear, or top-rear of the case, depending on where the opening is. Place the power supply into the case with the rear power slot facing the rear opening(See figure 9.2). Secure the power supply to the case with the screws supplied.

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| C:\Users\Clay\Dropbox\CMNS manual project assets\Power supply opening.gif  Figure 9.2: Power Supply Slot |

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| C:\Users\Clay\Dropbox\CMNS manual project assets\top fan openings.jpg  Figure 9.3: Fan Vents |

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*There may be fan openings on the top or bottom of the case(See figure 9.3). If the fan opening on the top of the power supply lines up with these it will help your airflow. If there is no vent then face the fan towards the motherboard*

# 10. Install GPU/Video Card

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| C:\Users\Clay\Dropbox\CMNS manual project assets\PCI.jpg  Figure 10.1: PCI Slots |

10.1 Most motherboards today come with a variety of PCI and PCI-Express (PCI-E) slots. Most video cards(GPU) are installed into the 16x PCI-E slot. To install, remove the video card from its packaging, being careful to only hold it on the sides and the fan assembly. The card will have an L shaped metal flange on the side that will fasten to the computer case(See figure 10.2) Once inserted, the metal flange can be fastened to the case with the provided screws.

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| ***C:\Users\Clay\Dropbox\CMNS manual project assets\graphics card flange.jpg***  Figure 10.2: Card Being Attached With A Phillips Screwdriver |

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*Some video cards can be extremely large. If possible you should determine the case and video cards dimensions before ordering. But if that was not possible then you can always move to HDD to a different slot to give yourself more room.*

# 11. Multiple Video Cards (Optional Section)

11.1 Computers are able to run multiple video cards simultaneously. To attach two or more of the same video card in either SLI (NVidia) or Crossfire (AMD), simply insert the other cards into the highest speed PCI-E lanes that are available, and connect them via the provided cable.

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| C:\Users\Clay\Dropbox\CMNS manual project assets\AMD-Radeon-HD-7950-CrossFire.jpg  Figure 11.1: Orange Crossfire Cable Connects Two Graphics cards |

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It is important that these video cards be of the same make and model. For example, if the first card you install is a GTX 980, then you must only use another GTX 980 for SLI.

# 12. PCI Cards (Optional Section)

12.1 Some users may wish to expand their computers capabilities. PCI cards can offer many different functionalities such as adding the ability to connect to wireless networks, connecting to Bluetooth devices, or increasing the number of USB interfaces. To install a PCI card, simply slide it into the keyed slot. Attach the metal flange to the computer case with the provided screws just like the video card.

# 13. Wiring Part 1

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*Computer components have used many different standards for wiring and connectors over the years. For the purpose of this manual, the current standards of SATA and ATX power will be used. If your components use another standard, such as IDE or Molex, consult your motherboard's manual.*

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*Many computer cases have options that make wire management easier, such as rubber grommets and a gap between the back motherboard plate and side panel, that allow you to run wires behind the motherboard.*

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| C:\Users\Clay\Dropbox\CMNS manual project assets\3 to 4 fans.png  Figure 13.1: Fan Connectors | C:\Users\Clay\Dropbox\CMNS manual project assets\4 to 3 fans.png | |  | | --- | | ***C:\Users\Clay\Dropbox\CMNS manual project assets\Quick tip Small.png*** | |

*3 Pin and 4 Pin connectors are cross-compatable. Just insert like in figure 13.1*

13.1 Plug any fans that installed in your case into the 3-pin or 4 pin fan connectors on your motherboard. Next attach any USB ports installed in your case to the motherboard with the appropriate wires. The motherboard connectors for USB should be clearly marked on your motherboard.

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| *C:\Users\Clay\Dropbox\CMNS manual project assets\USB connectors.jpg*  Figure 13.2: USB connectors |

13.2 The wires for your cases power and reset buttons, as well as any LEDs that your case may have, will have to connect to specific jumper prongs. These vary between different motherboards and manufacturers. Consult your motherboard manual for proper wiring of this step.

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| C:\Users\Clay\Dropbox\CMNS manual project assets\PSU_connectors.jpg  Figure 13.3: Motherboard and Some Video Card Connectors |

13.3 Attach the main 20 or 24-pin P1 connector to the matching socket on your motherboard. This connector will be keyed so that the thumb lever will mate with the slot on the motherboard socket. Next install the two remaining 3-pin connectors to your motherboard.

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| C:\Users\Clay\Dropbox\CMNS manual project assets\SATA Cables.jpg  Figure 13.4: SATA Cables |

13.4 Install drives to your motherboard with the provided SATA cables. SATA cable are keyed in an L shape for easy installation. Simply attach one end to your CD drive or storage drive, and the other end to your SATA ports on your motherboard.

13.5 Different video cards require different amounts of power from your power supply(See figure 13.3). Refer to your video card manual for correct wiring.

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*Modular and semi-modular power supplies can add or remove power cords as they need. They only require you to use the cords you need to power your components. There may be unused cords left over when you are finished wiring.*

# 14. Installing Monitor

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| C:\Users\Clay\Dropbox\CMNS manual project assets\Monitor ports.jpg  Figure 14.1: Monitor Ports |

14.1 To install the computer monitor, simply remove from packaging and connect cord to computer. Monitors can use different adapters such as DVI, HDMI, or VGA. Be sure that the monitor is plugged into one of the ports on the video card. Finally plug the monitor into a power source.

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*Motherboards also have video sockets to allow for on-board video capabilities. Plugging the monitor into these slots will give you weaker video performance than your video card. If you are having problems with video, check that your monitor is plugged into the video card, not the motherboard.*

# 15. Initial POST

15.1 POST, or Power On Self-Test, is the first procedure your computer will go through when you power it on. At this point you will not be able to fully boot your PC as it has no operating system installed. The purpose of this step is to trouble shoot any potential hardware or wiring problems before continuing with the build. Problems at this step will be easier to rectify than at the end of the build.

Connect the power cord to a power source and power on the PC. Many PCs have built in speakers that will make a single beep if the POST is successful. If you hear more than one beep there may be a problem with your hardware, for example 3 consecutive beeps means that the RAM may not be seated properly. If you do not hear a beep, it could just mean your PC doesn’t have on-board speakers. If this is the case, once you reach the splash page or BIOS of your motherboard, you will know that the POST is successful. At this point, power off the PC and continue with the build.

# 16. Wire Management (Optional Section)

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| ***C:\Users\Clay\Dropbox\CMNS manual project assets\wire1.jpg***  Figure 16.1: Tidily Managed Wires |

16.1 This step is optional, but encouraged. Having wires not properly tied down not only looks messy, but can impact the airflow through your case and impede cooling. Wires can be managed by using Velcro straps or plastic tie straps. Wires that run close to each other should be tied together, making a single cable run. If you have space for wire management behind the motherboard panel, there will be loops in the panel that you can thread a tie-strap through to secure wires to the panel.

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*Never use anything with metal inside the case such as twist-ties. They could contact your motherboard and cause a short.*

# 17. Peripherals

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| C:\Users\Clay\Dropbox\CMNS manual project assets\Common Peripherals.png  Figure 17.1: Common Peripherals |

17.1 Now is the time to move the re-attach the side panels to the case and move everything to its permanent location. Reattach the monitor to the PC video card, and the plug the monitor and PC into a surge protector. Attach keyboard, monitor, and any other peripherals to their needed sockets.

# 18. Final POST

18.1 After your monitor and peripherals are attached to your PC, power it on for a second and final POST. This post will tell you if anything has changed, such as wires becoming unattached during the wire management phase, or during moving. If the PC completes this POST successfully, the build is complete and you are ready to install the OS.

18.2 Insert the operating system disk and power on your computer. Follow the on screen instructions and your build will be complete.

**Appendix**: Designing Your Computer

Buying computers pre-built is usually more expensive than building a comparable computer. When building a computer, you have full control over what parts go into it, the operating system, the look of the PC, and more. When buying a pre-built, the buyer will have less choice, and less upgradability, in addition to possibly having "bloatware" using system resources from the get go.

If a buyer is willing to do a little research into parts ordering, and spend the time to do the build, they will have a better computer for less cost. Building a computer can, however, be intimidating. This appendix will offer some guidance as to what parts you should look for as per your build preference, and some valuable resources in researching and purchasing parts. These days, everyone can use computers, and everyone can build them too if they put in a little effort.

# Deciding on a Type of Build

Having an idea of what you will be using the computer for is a good first step in any build. The computer components you buy should depend on what functions you want your build to perform. General web-surfing/email machines need only a speedy processor, a small hard drive, and a minimum amount of RAM. These types of builds will often omit the expensive video card, relying solely on the on-board video capabilities of the processor.

Gaming machines on the other hand will need a moderate amount of RAM, a large hard drive or SSD, and a powerful video card. If you intend to use your computer to run photo and video editing programs, then a build with a large amount of high speed RAM is where you should be allocating your budget. Conversely, home theatre PC's (HTPC) need only a small amount of RAM, but a large hard drive to store movies and music.

# Budget

The first mistake many first time builders make is not budgeting properly. Buying the latest and greatest is always enticing, but depending on the purpose of your build, may be wasteful. Also, spending significantly less on one component may seem like saving money, but could end up slowing down the rest of your components. It is important to have a balanced build where all of the parts are working at full potential, and no power or money is going to waste. A great resource to use at this stage is [www.logicalincrements.com](http://www.logicalincrements.com), where they have a base of balanced builds ranging in price from $250 to over $4000.

# Shopping

To get the most out of your budget consider checking multiple retailers for parts. Different retailers often have sales at different times, and things like shipping cost can vary wildly. Always take some time to check your options before ordering parts. A great resource for shopping around, as well as ordering and checking for compatibility is [www.ca.pcpartpicker.com](http://www.ca.pcpartpicker.com). This site can even send you an email when a part drops below a certain price.

# Ordering

Many people choose to stretch out the time in ordering their components to get the best deals they can. This can save money, allowing you to buy better parts, but it can also cause a lot of headache. Computer parts generally have a limited window in which they can be returned for full price if they are faulty. Buying your parts over weeks or months will increase the time between purchasing them, and the time that you can test to make sure they are functioning optimally. Take this into consideration when ordering your parts.

# Compatibility

Compatibility between components is important in building computers, and knowing if all the parts will work together ahead of time can save frustration. While video cards and RAM from different manufacturers can work with most builds, things like the CPU can only be installed in certain motherboards. CPUs, even from the same manufacturer, often use different sockets, so care must be taken when ordering parts. Another thing that must be considered is how much power your components will require from the power source. [www.ca.pcpartpicker.com](http://www.ca.pcpartpicker.com) also has the functionality to tell you if all your components are compatible, and how much power they will draw so you can select the appropriate rated power supply.

# Conclusion:

If all the assembly steps were correctly followed then you now have a completed and functional computer. You may have built it for gaming or high demand work. Or it may just be for home theater and web browsing. There are many other places that hobbyists take computer building to such as case customization or overclocking. hopefully this machine continues to function well for years to come.