Introduction to the Raspberry Pi 3 Model B

Objective

This guide is to learn how to setup, connect to, and develop programs for the Raspberry Pi 3 Model B board (RPi).

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Part 1: Board setup

1. To begin, log on to your workstation's desktop computer (not the Raspberry Pi) using your Mizzou SSO username (your *pawprint*) and password.

2. You will be issued a MicroSD card that provides the RPi's Linux file system and software development tools. Remove (pull) the MicroSD card from its SD card adapter sleeve (see Figure 1). *Do not lose the MicroSD card or its SD card adapter sleeve; you have a responsibility to return the MicroSD card and the adapter sleeve at the end of the semester.*
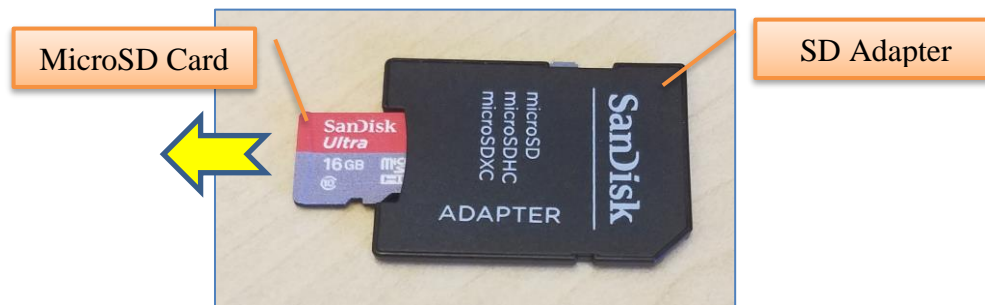

Figure 1.   Remove the MicroSD card from its SD card adapter.

3. Insert your MicroSD card into your workstation's RPi. Ensure the MicroSD card is oriented as shown in Figure 2 when inserting the card into the RPi's MicroSD card receptacle socket.
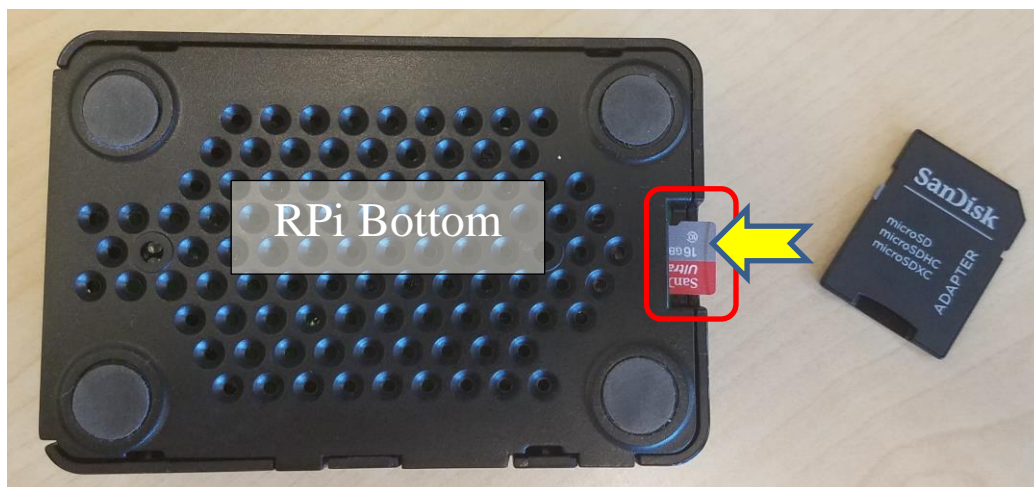
Figure 2.   The correct orientation for inserting the MicroSD card into the RPi's MicroSD card receptacle socket, which is located on the bottom of the RPi.

4. The RPi is powered from a power supply assembly that converts 120 VAC wall power into a regulated 5 VDC output voltage delivered via a Micro-USB plug, see Figure 3 (a). Connect the power supply's Micro-USB plug into the Micro-USB jack on side of the RPi, see Figure 3 (b). When 5 VDC is applied to the RPi's Micro-USB jack, the RPi immediately begins booting the

Linux operating system from the MicroSD card. The boot process takes approximately one minute to complete, whereupon the RPi is ready to use.

Figure 3.   Raspberry Pi 3 Model B power supply. (a) Adapter that converts 120 VAC wall power to regulated 5 VDC power via a Micro-USB plug.
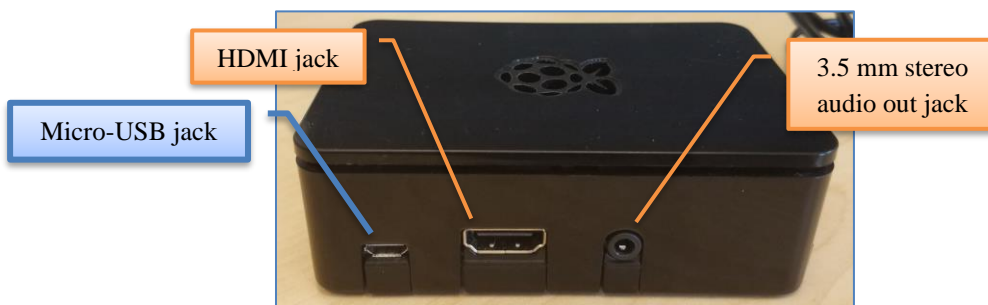

Figure 3.   (Continued.) Raspberry Pi 3 Model B power supply. (b) Location of the Micro-USB jack on the Raspberry Pi enclosure.

5. Software development tools are provided on the lab's desktop computers as well as on the MicroSD card that provides the RPi's runtime environment. You may use any text editor of your choosing—e.g., nano, pico, vim/gvim, emacs, Microsoft Visual Studio Code (*code*), etc.—to create and edit your source code files. You will use the GNU Compiler Collection (GCC) software "toolchain" that's installed on the RPi to translate your C/C++ source code files into executable image files (programs), libraries, etc. that are compatible with the Raspberry Pi 3 Model B's ARMv8-A superscalar microprocessor and hardware architecture.[1]

6. The examples that follow are based upon the assumption that you are using the Bash command shell whose command line prompts have the form `HOST $` (for non-root user accounts) where `HOST` is specified either as `Desktop` or `RPi`. Specifically, the prompt syntax `Desktop $` indicates command lines you invoke on the desktop computer, the prompt syntax `RPi $` indicates command lines you invoke on the Raspberry Pi. The actual command line is formatted as `dark blue text` that follows the dollar sign '`$`' prompt. Any text that follows a hashtag character '`#`' is considered a comment; you don't need to enter the hashtag or the comment text.

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[1] The RPI's CPU is a Broadcom BCM2837 system-on-chip (SoC) clocked at 1.2 GHz, whose quad cores are 32/64-bit ARM Cortex-A53 processors.

7. The RPi boards are *headless*—i.e., they are not directly connected to a keyboard, mouse, nor display. Therefore, you will use your desktop computer and the Secure Shell (SSH) client program `ssh(1)` [2] to remotely log on to your RPi, and then your desktop computer's keyboard, mouse, and display are shared between the desktop computer and the RPi. To do this on your desktop computer, open a Bash shell command prompt (a.k.a., a command line terminal) and at the Bash shell prompt **$** type in the SSH command line shown in Figure 4 (the dark blue text), where *RPI_IP_ADDRESS* is the actual IP address of the RPi you are using (see the comments that follow Figure 4).

```
# remotely log on to the RPi as user 'pi'
Desktop $ ssh -AY pi@RPI_IP_ADDRESS
# Or, remotely log on as the super-user 'root'
Desktop $ ssh -AY root@RPI_IP_ADDRESS
```

Figure 4.   Command line syntax for using the Secure Shell (ssh) program on the desktop computer to perform a "remote login" on the Raspberry Pi.

Your RPi's IP address has the format **128.206.22.1XX** where **XX** corresponds to the last two digits of the desktop computer your RPi is attached to. For example, if your RPi is attached to desktop computer **NAKA144-PC-05**, then your RPi's IP address is **128.206.22.105**, and therefore your SSH "remote login" command line would be as shown in Figure 5 if you want to log on as the user named 'pi':

```
Desktop $ ssh -AY pi@128.206.22.105
```

Figure 5.   Command line syntax for using the Secure Shell (ssh) program on the desktop computer to perform a "remote login" on the Raspberry Pi whose IP address is 128.206.22.105.

Notice that the options **-AY** are capitalized, and they are actually two separate options that are combined together: **-A** and **-Y**. As mentioned in the `ssh(1)` manual page, option '-A' forwards your SSH authentication agent from the local computer to user pi on the RPi, and option '-Y' enables trusted X11 forwarding between the RPi and the desktop computer. If you run a software app on the RPi that requires a graphical user interface (GUI), the -AY options allow the RPi app to render its GUI via the Linux desktop's display.

8. After you invoke the SSH remote login command you will be prompted to enter user pi's login password (Figure 6). The default login password is   **naka144pi**   (the password is case sensitive). For security reasons, no characters are displayed as you type in the password. Press

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[2] The parenthetical one '(1)' that follows the program name `ssh` informs you that the manual for the SSH client program `ssh` is provided in section one of Linux's manual system. You can view this manual by entering the command line `man ssh` or `man 1 ssh` at a command shell prompt. When viewing any manual, pressing the 'q' key quits/exits the manual viewer.

the keyboard's ENTER after you type in the password. *(NB: This is the default login password for all the RPi boards in the lab, for both the 'pi' and 'root' user logins.)*

```
Desktop $ ssh -AY pi@128.206.22.105
pi@128.206.22.105's password:
```

Figure 6.   The SSH program on the desktop computer prompts you to enter the password for user 'pi' on the Raspberry Pi.

9. You should now be remotely logged on to the RPi at your workstation.

10. When you finish using your RPi, **ALWAYS, ALWAYS, ALWAYS** shut it down properly by logging onto the RPi and invoking the **shutdown(8)** program; otherwise you risk corrupting the Linux file system on your MicroSD card, **resulting in the unrecoverable loss of all your hard work**.

    To properly shut down your RPI, invoke the **shutdown** command shown in Figure 7 at the RPi's command prompt. This command tells the RPi's Linux operating system to "shutdown/halt now", whereupon the Linux operating system begins its controlled shut down procedure. The SSH "remote login" connection between the desktop computer and the RPi closes immediately after you invoke the **shutdown** command; the desktop computer will receive no further communications from the RPi. **Wait 30 seconds after invoking the shutdown program to allow the Linux operating system to fully shut down the RPi.**

```
# if logged in as user 'pi'
RPi $ sudo shutdown -h now

# Or, if logged in as user 'root'
RPi $ shutdown -h now
```

Figure 7.   Using the shutdown(8) program to properly shut down the Raspberry Pi when you are done using it.

11. Power off the RPi by unplugging the micro-USB plug from the RPi's Micro-USB jack (see Figure 3).

12. Remove your MicroSD card from the RPi (see Figure 2). Please be careful when doing so; you do not want to damage the RPi or your MicroSD card. It is recommended that you store your MicroSD card inside its SD card ADAPTER jacket to protect the MicroSD card, to make the MicroSD card easier to see/locate, and to prevent separation and loss of the MicroSD card or its SD adapter jacket (both of which you must return at the end of the term).