【Part A】

1. Explain in detail about the low powered computers such as Raspberry Pi. Explain on its benefits and challenges and compare the versions (Raspberry Pi 1 and Raspberry Pi 4). (10 marks).

INTRODUCE:

The Raspberry Pi was developed by the Raspberry Pi Foundation, a UK-registered charity led by Eben Upton and E Upton. In March 2012, Cambridge University's (Eben Epton) launched the world's smallest desktop computer, which is the size of a credit card but has all the basic functions of a computer. The Raspberry Pi, or Raspberry Pi in Chinese, is the world's smallest desktop computer. The foundation aims to improve education in computer science and related subjects in schools and make computers fun. The foundation expects the computer to be used in many other applications, both in developing and developed countries. It is a based on ARM micro computer motherboards, SD card as hard drives, memory CARDS around the motherboard, there are two USB ports and a front-end ports, can connect the keyboard, mouse, and network cable, also has the video analog signal television output interface and HDMI hd video output interface, and integrate the above parts all in a motherboard only slightly bigger than a credit card, With all the basic functions of a PC, you just need to plug in your TV and keyboard to perform functions like spreadsheets, word processing, games, and high-definition videos. The Raspberry Pi B model only comes with a tablet, with no memory, power, keyboard, case or wiring.

Disadvantages of the raspberry pie:

Disadvantage 1：There is no fuse protection on the Rpi, so the circuit board can be damaged if the pins are not connected correctly

Disadvantage 2: In terms of CPU processing speed, it's not as fast as a traditional PC or laptop.

Disadvantage 3: There is no analog to digital conversion built into GPIO pins like in Arduino. Therefore, when you need more precision, you need to use an ADC chip to process analog signals.

Advantages of the raspberry pie:

Advantage 1: You can install a full operating system (for example, Raspbian for Linux or Windows IOT Core for Windows OS) and use it as your everyday computer

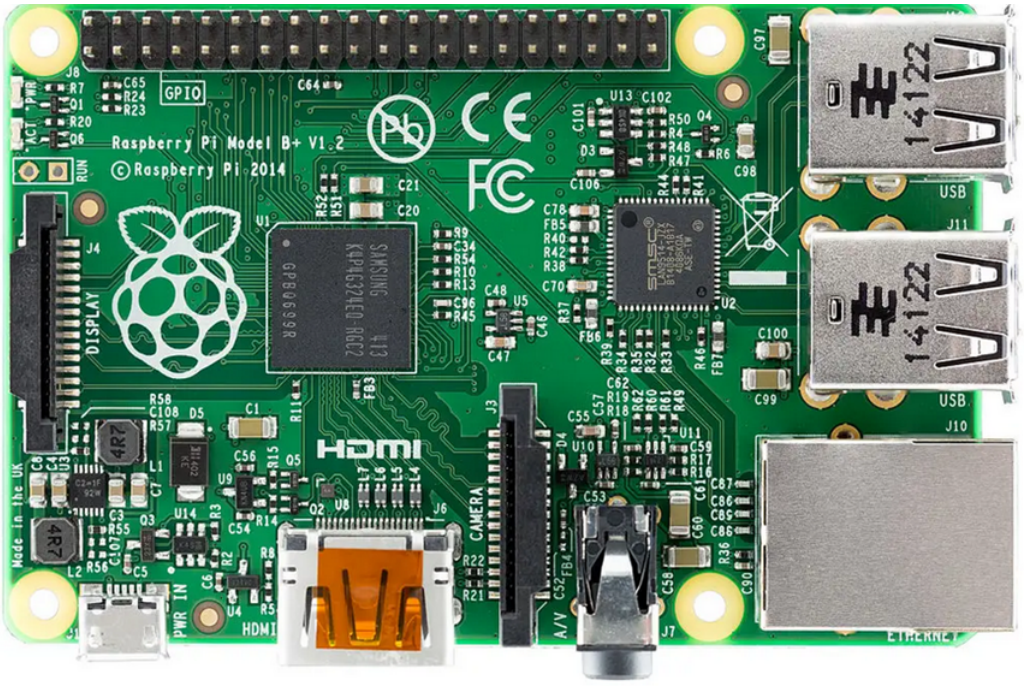
Advantage 2: The presence of GPIO (general-purpose input/output pins) is what sets the RPi apart from traditional computers. You can connect these pins to sensors and external components and interact with them programmatically using languages like Python. This enables you to build and prototype iot devices that can sense the real world

Advantage 3: Newer models such as the RPi have built-in wifi and Bluetooth. This allows you to easily put projects into wireless mode.

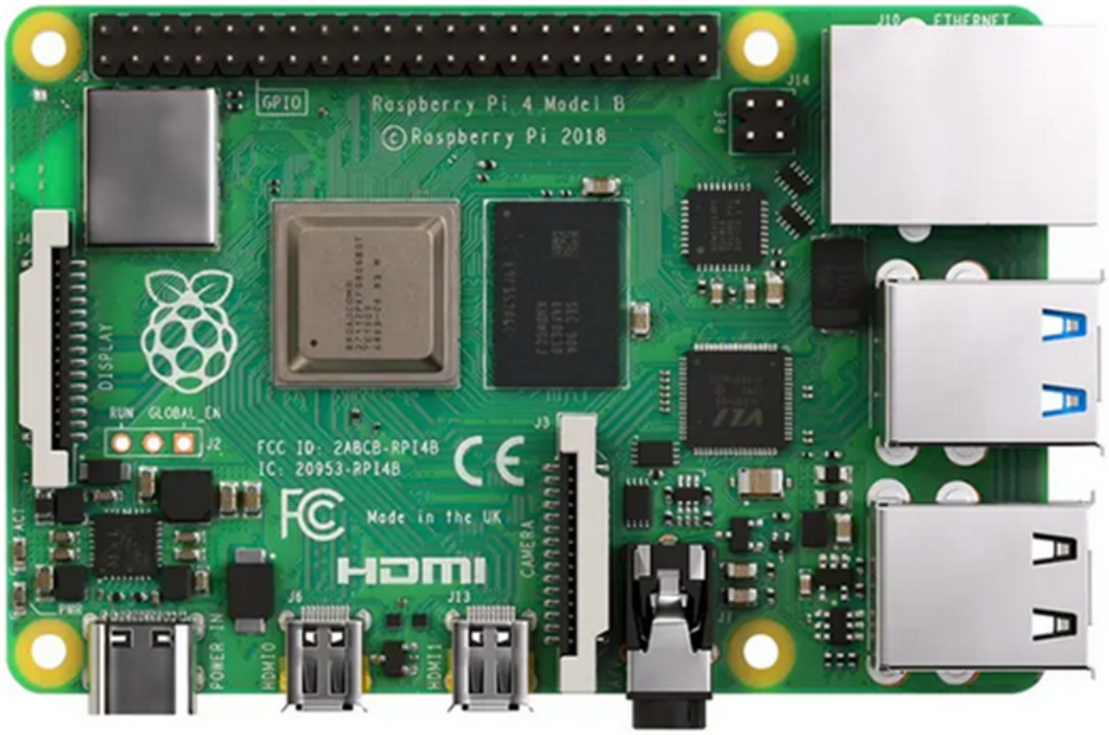
Advantage 4: The Raspberry PI is small and portable, with I/O ports and modular programming

Compare raspberry PI 1 and Raspberry PI 4:

Picture of Raspberry PI 1



Picture of Raspberry PI 4B



Configuration details	Raspberry PI 4B	Raspberry PI 1
CPU	4-core broadcomBCM2711 (Cortex A72)	ARM1176JZF-S 700MHz
memory	1-4GB DDR4	256M
GPU	500MHz VideoCore VI	Broadcom VideoCoreIV
Video output	Two micro HDMI terminals	15 the needle
Maximum resolution	4K 60Hz 1080p or two 4K 30Hz	640x350
USB port	Two USB3.0+ two USB2.0	one USB2.0
Wired network	Gigabit Ethernet	Null

wireless network	**802.11ac（2.4/5GHz） Bluetooth 5.0**	**Null**
Power supply port	**Type-C (5V 3A)**	**MicroUSB（5V 300mA）**
size	**3.5x2.3x0.76 inch (88*58*19.5) mm**	**86x56x20mm**
weight	**46g**	**45g**

2.Give one example of successful implemented using Raspberry Pi 3 or Raspberry Pi 4 project in detail with the architecture designs. Write the steps to construct the hardware. You may refer to a video and cite the video. The implementation must be related to energy saving, recycling or healthy lifestyle. (15 marks)

Garbage classification is becoming more and more important in our daily life. Proper recycling of garbage can make our life healthier, save energy and improve our life. Therefore, I found a garbage classification project using raspberry PI. As for the specific project content, I used the following video to explain. There are seven videos. Everything is clearly explained.

1. Project scheme introduction：
https://www.bilibili.com/video/BV1RV411x7BN?p=1

2. Environment setup and local training code.:
https://www.bilibili.com/video/BV1RV411x7BN?p=2

3. Environment code deployment:
https://www.bilibili.com/video/BV1RV411x7BN?p=3

4. Hardware configuration and installation:
https://www.bilibili.com/video/BV1RV411x7BN?p=4

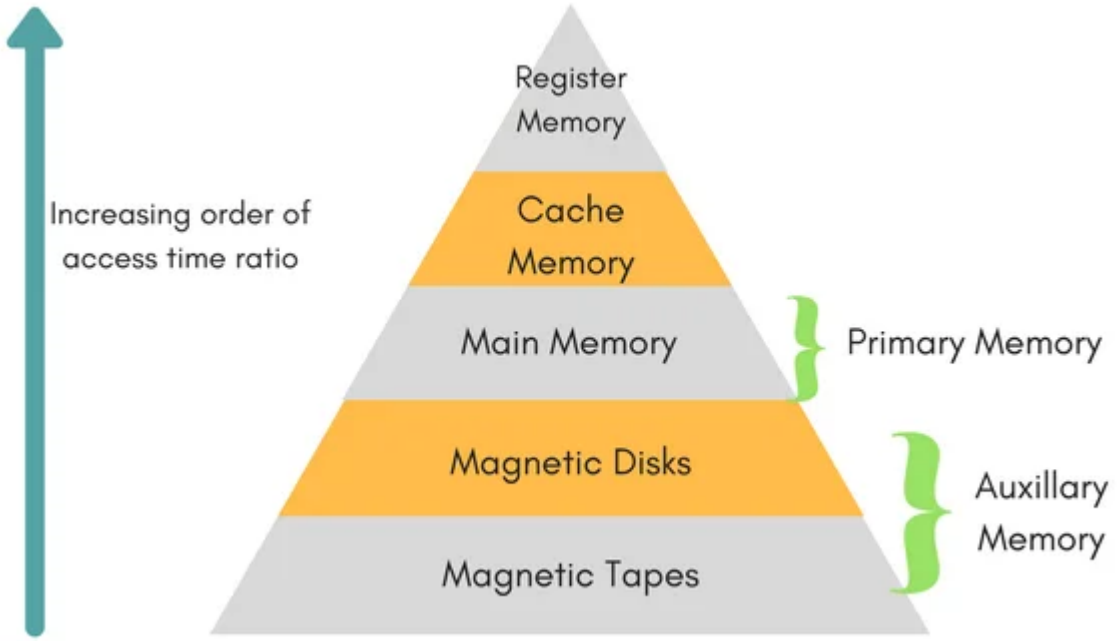
5. Raspberry PI system and interface configuration:
https://www.bilibili.com/video/BV1RV411x7BN?p=5

6. Front-end interface code and packaging:
https://www.bilibili.com/video/BV1RV411x7BN?p=6

7. Finished product Project Display:
https://www.bilibili.com/video/BV1RV411x7BN?p=7

【Part B】

1. Computer Memory Hierarchy separates computer storage into a hierarchy based on response time. Memory of the computer can be separated to five hierarchies based on the speed as well as use.
   Types of levels in the memory are registers, cache, main memory, magnetic disc, and magnetic tapes.The first three hierarchies are volatile memories which mean when there is no power, and then automatically they lose their stored data. Whereas the last two hierarchies are not volatile which means they store the data permanently.



2. Volatile Memory: This is memory that is only functional for as long as it is powered. When power is removed, it loses its stored value, although it can be used as temporary data storage memory. Generally, this type of memory uses simple semiconductor technology and is easier to write to from an electrical point of view. It is also called RAM (Random Access Memory) or data memory.

   Non-volatile Memory: This is memory that retains its stored value even when power is removed. On a desktop computer this function is achieved primarily via the hard disk, a huge non-volatile store of data. In an embedded system it is achieved using non-volatile semiconductor memory. It is a greater challenge to make non-volatile memory, and sophisticated semiconductor technology is applied. Generally, this type of memory has been more difficult to write to electrically, for example in terms of time or power taken, or complexity of the writing process. Non-volatile memory is used for holding the computer program and it is also called ROM (Read-Only Memory) or program memory.

3. Latency deals with how fast the RAM module can access its own hardware. Lower latency means faster data access, thus faster data transfer to the CPU, and faster operation of your computer overall. And high latency means slower data access and slow data transfer to the CPU. Higher-quality, more expensive RAM has lower latency.

4. In cache memory, it provides a condition for the central processor unit (CPU) to run at gigahertz frequencies. Cache, which is an extension of a computer main memory. It is a supplementary memory system that temporarily stores frequently used instruction and data for quicker processing by the CPU.

   Virtual memory is a technique that increases the main memory capacity. With a use of data swap technology, it allows the hard disk area to use as a virtual memory. It is a technology that allows the computer to have an extra memory but it is slower compared to the cache memory when accessing the data.

5. Cache hierarchy models can be optionally added to a Simics system, and the system configured to send data accesses and instruction fetches to the model of the cache system. Based on the cache simulation, it is possible to determine the hit and miss rate of caches at different levels of the cache hierarchy.

6. Machine cycle contains 4 processes. The first process is the fetch process which retrieves an instruction from the memory. After that, the decode process translates the instructions retrieved to a series of computer commands. In the third process which is the execution process that executes the computer commands. Lastly, the

store process sends and writes the result back to the computer which decreases the memory usage of the computer.

【Part C】

1.

Step 1 : [Truth Table]

A	B	C	D	Y
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	1
1	1	0	1	1
1	1	1	0	0
1	1	1	1	1

Step 2 : Write the AND term for each case where the output is 1.

Y = 1 when, A'BCD, ABC'D', ABC'D, ABCD', ABCD

Step 3 : Write the sum-of-products(SOP) expression for the output.

[Karnaugh Map]

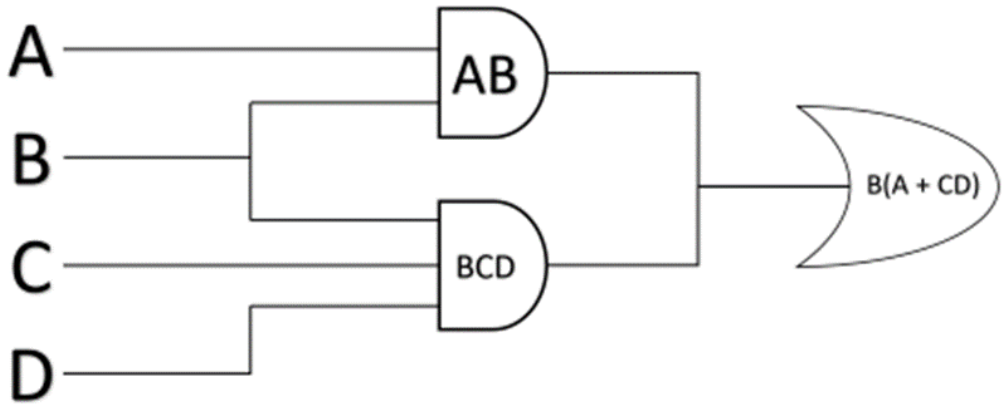
CD \ AB	00	01	11	10
00			1	
01			1	
11		1	1	
10			1	

Due to the K-map, Y = AB + BCD

Step 4 : Simplify the SOP expression.

Y = AB + BCD
Y = B(A + CD)

Step 5 : Implement the circuit for the final, simplified expression.



2.

Step 1 : [Truth Table]

A	B	C	Output
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1

1	0	1	0
1	1	0	0
1	1	1	0

Step 2 : Write the AND term for each case where the output is 1.

Output = 1 when, A'B'C', A'B'C, A'BC', AB'C'

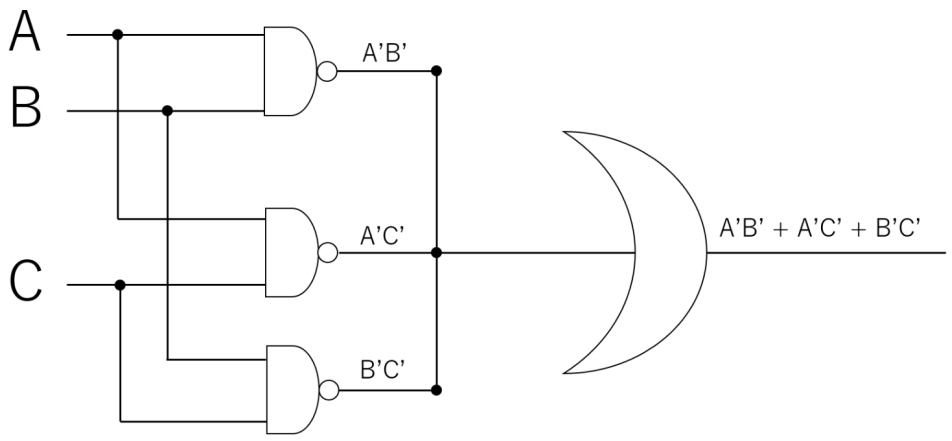
Step 3 : Write the sum-of-products(SOP) expression for the output.

Output = A'B'C' + A'B'C + A'BC' + AB'C'

Step 4 : Simplify the SOP expression.

Output = A'B'C' + A'B'C + A'BC' + AB'C'
Output = A'B'C' + A'B'C + A'BC' + AB'C' + A'B'C' + A'B'C'
Output = A'B'C' + A'B'C + A'BC' + A'B'C' + AB'C' + A'B'C'
Output = A'B'(C' + C) + A'C'(B' + B) + B'C'(A' + A)
Output = A'B' + A'C' + B'C'

Step 5 : Implement the circuit for the final, simplified expression.



3.

Step 1 : [Truth Table]

Input				Output	
A	B	C	D	N-S	E-W
0	0	0	0	0	1

0	0	0	1	0	1
0	0	1	0	0	1
0	0	1	1	0	1
0	1	0	0	1	0
0	1	0	1	0	1
0	1	1	0	0	1
0	1	1	1	0	1
1	0	0	0	1	0
1	0	0	1	0	1
1	0	1	0	0	1
1	0	1	1	0	1
1	1	0	0	1	0
1	1	0	1	1	0
1	1	1	0	1	0
1	1	1	1	0	1

Step 2 : Write the AND term for each case where the output is 1.

AND for E-W : A'B'C'D', A'B'C'D, A'B'CD', A'B'CD, A'BC'D, A'BCD',
A'BCD, AB'C'D, AB'CD', AB'CD, ABCD

AND for N-S : A'BC'D, AB'C'D', ABC'D', ABC'D, ABCD'

Step 3 : Write the sum-of-products(SOP) expression for the output.

N-S = A'BC'D + AB'C'D' + ABC'D' + ABC'D + ABCD'

E-W = A'B'C'D' + A'B'C'D + A'B'CD' + A'B'CD + A'BC'D + A'BCD' + A'BCD +
AB'C'D + AB'CD' + AB'CD + ABCD

Step 4 : Simplify the SOP expression.

N-S = A'BC'D + AB'C'D' + ABC'D' + ABC'D + ABCD'
N-S = A'BC'D' + ABC'D' + AB'C'D' + ABC'D' + ABC'D + ABC'D' + ABCD' +
ABC'D'

N-S = BC’D’(A’ + A) + AC’D’(B’ + B) + ABC’(D’ + D) + ABD’(C’ + C)
N-S = BC’D’ + AC’D’ + ABC’ + ABD’

E-W = (N-S)’

Step 5 : Implement the circuit for the final, simplified expression.