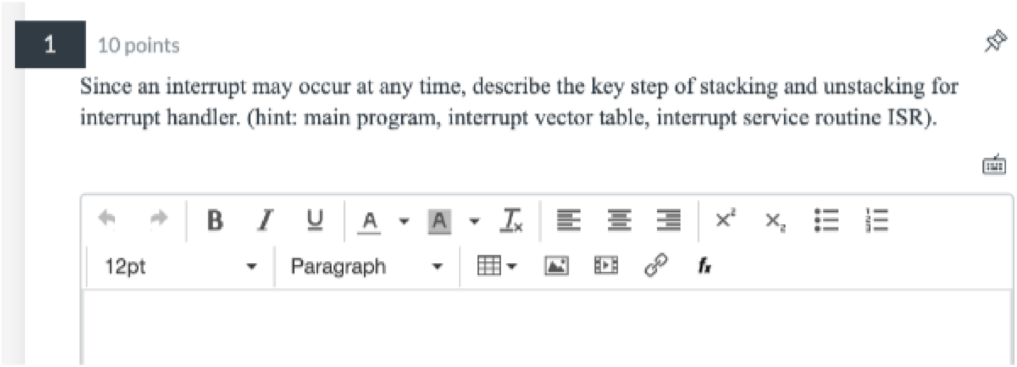
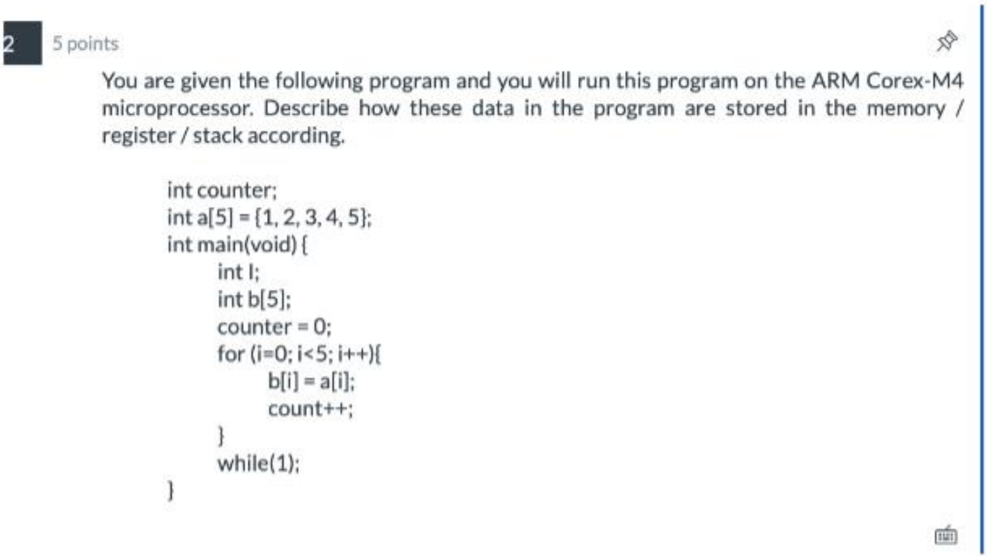


1 10 points

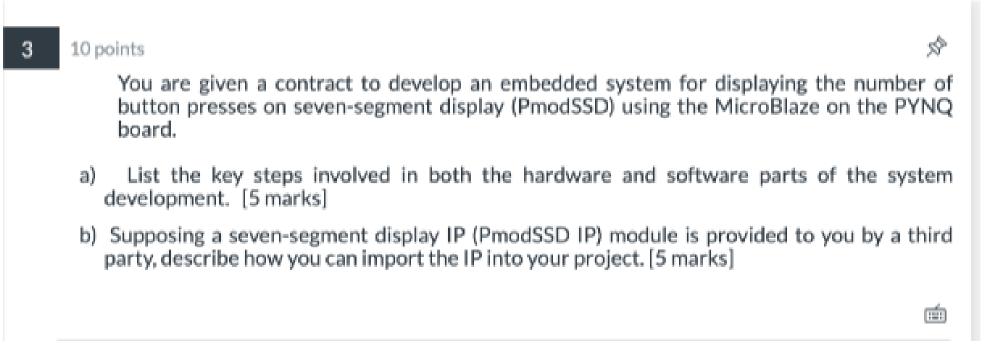
Since an interrupt may occur at any time, describe the key step of stacking and unstacking for interrupt handler. (hint: main program, interrupt vector table, interrupt service routine ISR).



2 5 points

You are given the following program and you will run this program on the ARM Corex-M4 microprocessor. Describe how these data in the program are stored in the memory / register / stack according.

```
int counter;
int a[5] = {1, 2, 3, 4, 5};
int main(void) {
      int I;
      int b[5];
      counter = 0;
      for (i=0; i<5; i++){
            b[i] = a[i];
            count++;
      }
      while(1);
}
```



3 10 points

You are given a contract to develop an embedded system for displaying the number of button presses on seven-segment display (PmodSSD) using the MicroBlaze on the PYNQ board.

a) List the key steps involved in both the hardware and software parts of the system development. [5 marks]

b) Supposing a seven-segment display IP (PmodSSD IP) module is provided to you by a third party, describe how you can import the IP into your project. [5 marks]

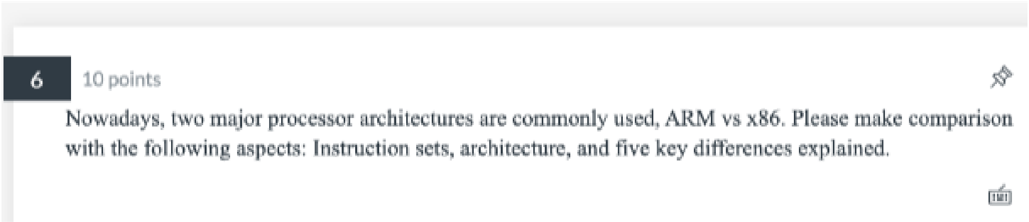
5 10 points

Given a Nucleo F401 STM microcontroller board, answer the following.

a) Name the processor and microcontroller used by the board. [4 marks]

b) Briefly describe how you can use Mbed platform to develop a program and run it on the board. [4 marks]

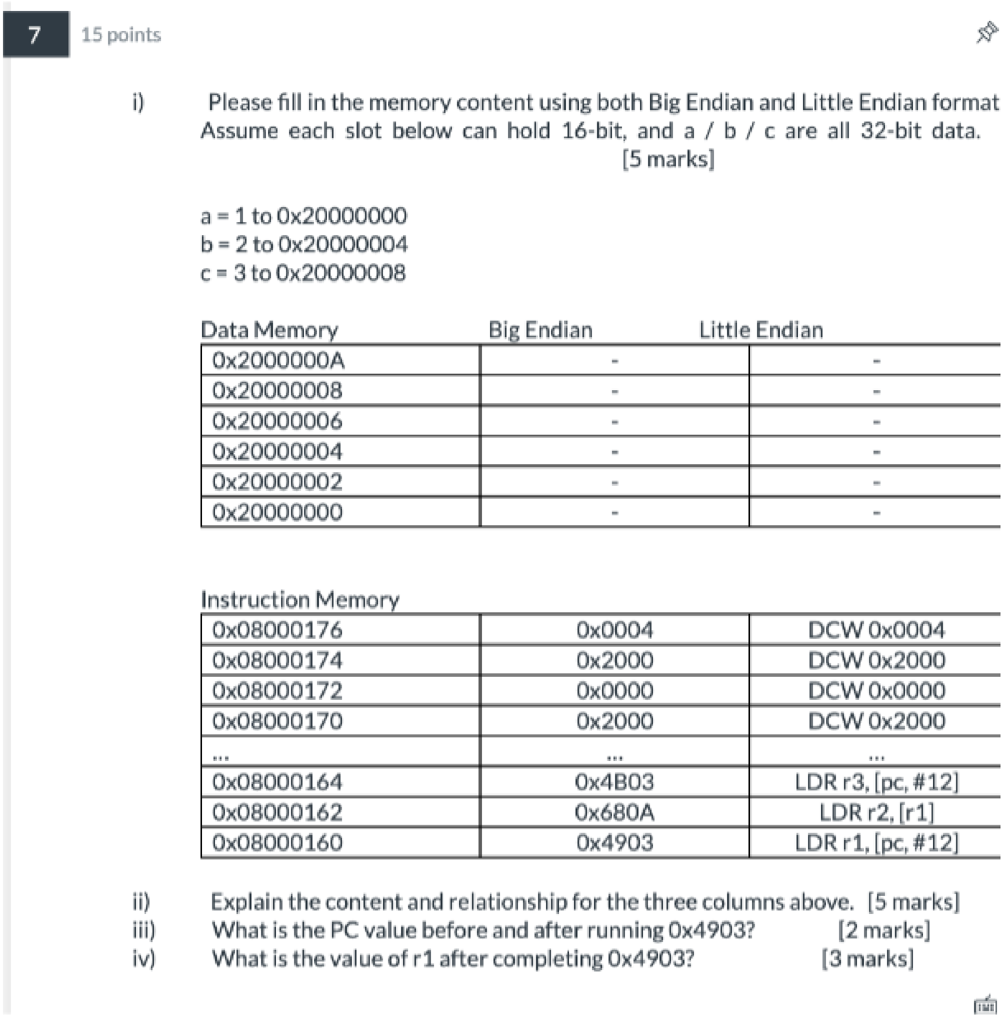
c) Give one difference between ARM development studio and the ARM Mbed platform. State the advantage of each over the other. [2 marks]



6

10 points

Nowadays, two major processor architectures are commonly used, ARM vs x86. Please make comparison with the following aspects: Instruction sets, architecture, and five key differences explained.



7

15 points

i) Please fill in the memory content using both Big Endian and Little Endian format Assume each slot below can hold 16-bit, and a / b / c are all 32-bit data. [5 marks]

a = 1 to 0x20000000
b = 2 to 0x20000004
c = 3 to 0x20000008

Data Memory	Big Endian	Little Endian
0x2000000A	-	-
0x20000008	-	-
0x20000006	-	-
0x20000004	-	-
0x20000002	-	-
0x20000000	-	-

Instruction Memory

0x08000176	0x0004	DCW 0x0004
0x08000174	0x2000	DCW 0x2000
0x08000172	0x0000	DCW 0x0000
0x08000170	0x2000	DCW 0x2000
...	...	...
0x08000164	0x4B03	LDR r3, [pc, #12]
0x08000162	0x680A	LDR r2, [r1]
0x08000160	0x4903	LDR r1, [pc, #12]

ii) Explain the content and relationship for the three columns above. [5 marks]
iii) What is the PC value before and after running 0x4903? [2 marks]
iv) What is the value of r1 after completing 0x4903? [3 marks]

8 10 points

Consider the following table of arrival time and burst time for three processes P0, P1 and P2.

Process	Arrival time	Burst Time
P0	0 ms	9 ms
P1	1 ms	4 ms
P2	2 ms	9 ms
P3	3 ms	5 ms

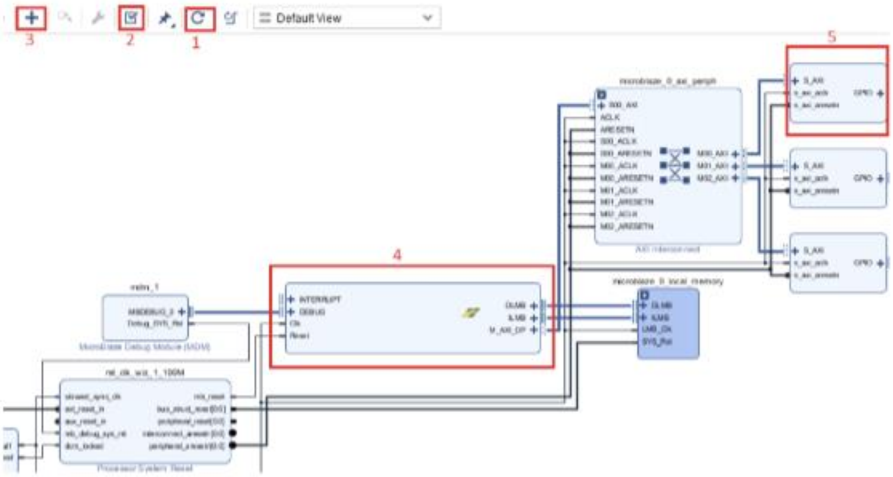
(a) The shortest remaining time scheduling algorithm is used. Scheduling is carried out only at arrival or completion of processes. What is the average waiting time for the three processes? Please draw the figures of all the process.

(b) Assume that the required CPU time is not known, what kind of scheduling algorithm will you select? Give a solution and draw the process figure.

Drag n' Drop here or Browse

9 10 points

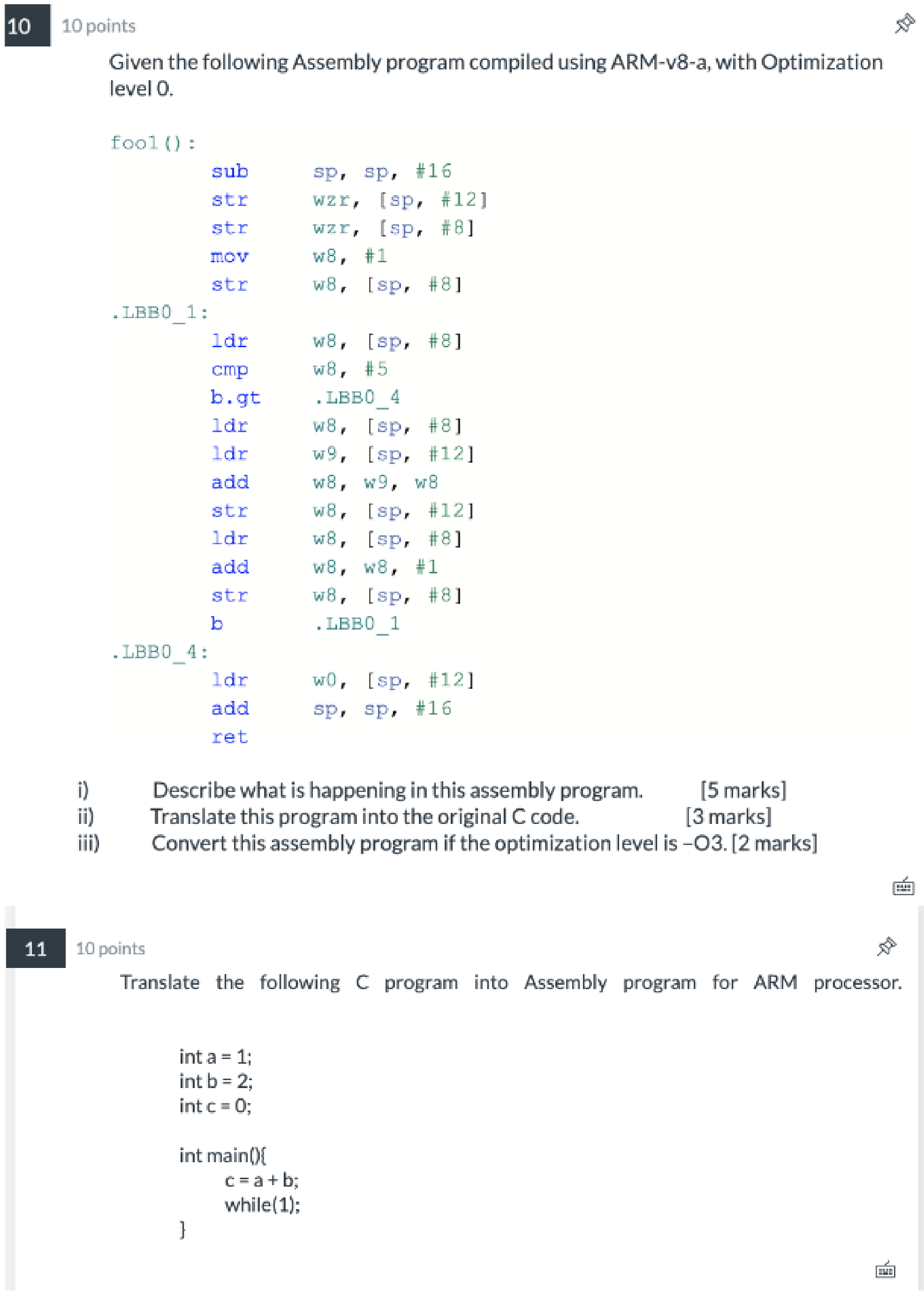
The figure below shows the block design of an embedded system built on a PYNQ board.



a) Identify and state the functions of the labelled items 1-5 in the figure. [5 marks]

b) What need to be done after generating the bitstream before the software development? [2 marks]

c) Which tool is used for the software development, briefly describe how to build the program and program the FPGA from the tool? [3 marks]



10

10 points

Given the following Assembly program compiled using ARM-v8-a, with Optimization level 0.

```
foo1():
        sub     sp, sp, #16
        str     wzr, [sp, #12]
        str     wzr, [sp, #8]
        mov     w8, #1
        str     w8, [sp, #8]
.LBB0_1:
        ldr     w8, [sp, #8]
        cmp     w8, #5
        b.gt    .LBB0_4
        ldr     w8, [sp, #8]
        ldr     w9, [sp, #12]
        add     w8, w9, w8
        str     w8, [sp, #12]
        ldr     w8, [sp, #8]
        add     w8, w8, #1
        str     w8, [sp, #8]
        b       .LBB0_1
.LBB0_4:
        ldr     w0, [sp, #12]
        add     sp, sp, #16
        ret
```

i) Describe what is happening in this assembly program. [5 marks]
ii) Translate this program into the original C code. [3 marks]
iii) Convert this assembly program if the optimization level is –O3. [2 marks]

11

10 points

Translate the following C program into Assembly program for ARM processor.

```
int a = 1;
int b = 2;
int c = 0;

int main(){
        c = a + b;
        while(1);
}
```