

SECTION A

1. What is an embedded system, and what are components of an embedded system? **(2 marks)**
2. What is a micro-controller? **(2 marks)**
3. What is a fundamental difference between micro-controllers and microprocessors? **(2 marks)**
4. Give 3 reasons for using a microcontroller instead of general-purpose computer **(3 marks)**
5. What is security in an embedded system? **(2 marks)**
6. What is safety in an embedded system? **(2 marks)**
7. How does security affect safety of an embedded system? **(3 marks)**
8. What's the basic difference between RISC and CISC architecture? **(2 marks)**
9. State 3 challenges that are often faced in designing embedded systems **(8 marks)**
10. What are the 5 steps of the embedded design methodology? **(5 marks)**
11. Briefly describe the distinction between requirements and specification of an embedded system **(2 marks)**
12. Briefly describe the distinction between specification and architecture of an embedded system **(2 marks)**
13. What is quantisation and when is it used in embedded systems? **(2 marks)**
14. Given an analogue signal varying from 0 to 10V, how many bits of ADC would we need to achieve a 0.01V (2 decimal points) resolution? **(3 marks)**

SECTION B

1. Analyze the code snippet below to answer the follow-on questions

```
1. int x;  
2. short *y;  
3. void functionX (void);  
4. void functionX (void)  
5. {  
6.     unsigned char i, j;  
7.     for (i = 0; i < 10; i++)  
8.     {  
9.         for (j = 0; j < 5; j++)  
10.        {  
11.            int k = 10;  
12.            x += k + i;  
13.        }  
14.        *y = x * i;  
15.    }  
16. }
```

i = 0 j = 0 k = 10
x = 10 + 0

y = 10 * 0 = 0

x += y

x = x + y

x = x + (k + i)

- Explain what the code snippet does. (3 marks)
 - Use a table to make a trace of the values of the variables up to iteration i = 3. (5 marks)
 - What are pointers in C/C++ and what are they often used for in Embedded systems (2 marks)
 - Explain the scope of each variable (2.5 marks)
 - What is the difference between the variables of type **int** and **short**. How many bits are commonly used for each type and what is the maximum unsigned value each can represent (2.5 marks)
 - Re-write the code to use while loops instead of for loops (5 marks)
2. Push buttons are used in a variety of embedded applications to trigger or stop an action when someone or something presses the switch. However, due to the mechanical nature of the switches, a single push on the switch might be interpreted as multiple presses. Using the Atmega 328p and the Appendix:
- Write a program in C/C++ that monitors and debounces an input switch. (10 marks)
 - Modify your code in 2.a such that a DC motor turns on when a user presses the switch the first time, and turns off when the user presses the switch a second time. (10 marks)

3. Time delays are regularly used in embedded systems to determine when a given operation starts or stops executing. Using the Atmega 328p and Appendix:
- Use Timer interrupts and counter 1 to make an LED connected on a PIN of your choice on PORTB to blink on and off. Use the sample code below as a guide to help you write the complete code in C/C++ needed. **(10 marks)**

```
ISR(TIMER1_COMPA_vect)
{
    //code
}

int main()
{
    //code
    TIMSK1 = 0b00000010;
    sei(); //enable global interrupts
}
```

- What is the clock period when the clock select pins are set to 101 **(4 marks)**
- Re-write this program to use an already existing time delay library `_delay_ms()` and a polling mechanism **(6 marks)**

10k frequency is 16 Mega Hz

4. As a growing embedded start-up company, you have been approached by a local government to help them develop an early warning system for wildfires. The client wants portable wireless smoke detectors that are the size of a smartphone. They want to deploy the smoke detectors across a forest conservation that spans 200 hectares. The devices need to be easily placed on tree trunks by forest rangers as they walk through the forest. Due to forest canopy cover, the devices cannot be solar powered, and neither can they have a GPS module to determine their location in real time, so it has been proposed that a sector identification number (SiD) representing different sections of the forest, shall be manually programmed into each device by the user (forest ranger) at time of deployment. Each unit should cost no more \$10 and will use LoRaWAN to transmit its data. Furthermore, each device will be battery powered.

- Write up a requirements document for this embedded system **(5 marks)**
- A hectare is approximately 100m length, and 100m width.
 - If each smoke detector can detect smoke in an area of 10000m^2 how many smoke detectors would be needed to cover the whole forest. **(2marks)**
 - How many bits would be needed to store the SiD and in which memory would this value best be stored considering that batteries might have to be swapped occasionally. **(2 marks)**
- Propose how the SiD can be input into a device, considering the process must be as user friendly as possible keeping in mind the device constraints. Augment your answer with pseudo code or flow diagram. **(5 marks)**
- Present a high-level Architecture design using block diagrams **(6 marks)**

Purpose

Inputs

Outputs

Functionality

manufacturing cost

Power

Physical size and weight