

AME 3623 Real-Time Embedded Systems  
Midterm  
March 8, 2018

General instructions:

- Please wait to open this exam booklet until you are told to do so.
- This examination booklet has 10 pages. You also have been issued a bubble sheet.
- Write your name, university ID number and date, and sign your name below. Also, write your name and ID number on your bubble sheet, and fill in the bubbles for your ID.
- The exam is closed book, notes and electronic devices. The exception is that you may have one page of personal notes (double sided).
- The exam is worth a total of 137 points (and 10% of your final grade).
- You have 1.25 hours to complete the exam. Be a smart test taker: if you get stuck on one problem go on to the next.
- Use your bubble sheet to answer all multiple-choice questions. Make sure that the question number and the bubble row number match when you are answering each question.

On my honor, I affirm that I have neither given nor received inappropriate aid in the completion of this exam.

**Signature:** \_\_\_\_\_

**Name:** \_\_\_\_\_

**ID Number:** \_\_\_\_\_

**Date:** \_\_\_\_\_

Question	Points	Score
Binary Representations and Mathematical Operators	34	
Circuits	30	
Digital/Analog Systems	18	
Finite State Machines	17	
Digital I/O	24	
Serial Processing	14	
Total:	137	

Part I. Binary Representations and Mathematical Operators

1. (6 points) What is the hexadecimal representation of  $c$  after the following code is executed?

```
uint8_t a = 0x28;  
uint8_t b = 0x30;  
uint8_t c = b ^ a; // XOR
```

A.  $0x0$    B.  $0x10$    C.  $0x18$    D.  $0x38$    E. Answer not shown

2. (4 points) What is the binary representation of  $a$  after the following code is executed?

```
uint8_t a = 0x16;
```

A. 0000 1000   B. 0001 0000   C. **0001 0110**   D. 0001 1100  
E. Answer not shown

3. (4 points) What is the binary representation of  $c$  after the following code is executed?

```
uint8_t a = 0xA5;  
uint8_t b = a >> 2;;  
uint8_t c = b + 5;
```

A. 0010 1001   B. **0010 1110**   C. 1001 0100   D. 1001 1001  
E. Answer not shown

4. (4 points) What is the decimal representation for the binary digits 0100 1001?

A. 65   B. 69   C. **73**   D. 81   E. Answer not shown

5. (4 points) What is the decimal representation of  $d$  after the following code is executed?

```
uint16_t a = 27;  
uint16_t b = a << 4;  
uint16_t c = b >> 8;  
uint16_t d = c << 2;
```

A. 0   B. **4**   C. 6   D. 27   E. Answer not shown

6. (4 points) What is the decimal value of  $c$  after the following code is executed?

```
uint8_t a = 127;
uint8_t b = 129;
uint8_t c = a & b
```

A. 0    **B. 1**    C. 127    D. 129    E. Answer not shown

7. (4 points) What is the hexadecimal representation of  $c$  after the following code is executed?

```
uint8_t a = 0x27;
uint8_t b = 0x42;
uint8_t c = a | b;
```

A. 0x0    B. 0x1    C. 0x10    **D. 0x67**    E. Answer not shown

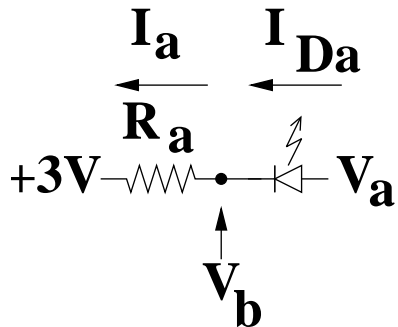
8. (4 points) What is the binary representation of  $c$  after the following code is executed?

```
uint8_t a = 17;
uint8_t b = 0x10;
uint8_t c = a + b;
```

A. 0001 1100    **B. 0010 0001**    C. 0010 1011    D. 0010 0111  
E. Answer not shown

Part II. Circuits

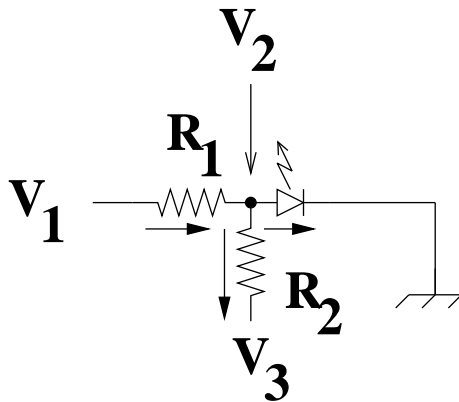
Consider the following circuit:



Assume  $R_a = 1000\Omega$  and  $V_{f_a} = 2V$ .

9. (6 points) If  $V_b = 10 V$ , what is  $V_a$ ?  
 A. 0 V    B. 2 V    C. 10 V    **D. 12 V**    E. Answer not shown
  
10. (6 points) If  $V_a = 6 V$ , what is  $I_a$ ?  
 A. 0 mA    **B. 1 mA**    C. 3 mA    D. 6 mA    E. Answer not shown
  
11. (6 points) If  $V_a = 2 V$ , what is  $V_b$ ?  
 A. 0 V    B. 2 V    **C. 3 V**    D. 4 V    E. Answer not shown

Consider the following circuit:



Assume  $R_1 = 100 \Omega$ ,  $R_2 = 300 \Omega$  and  $V_f = 1 V$ .

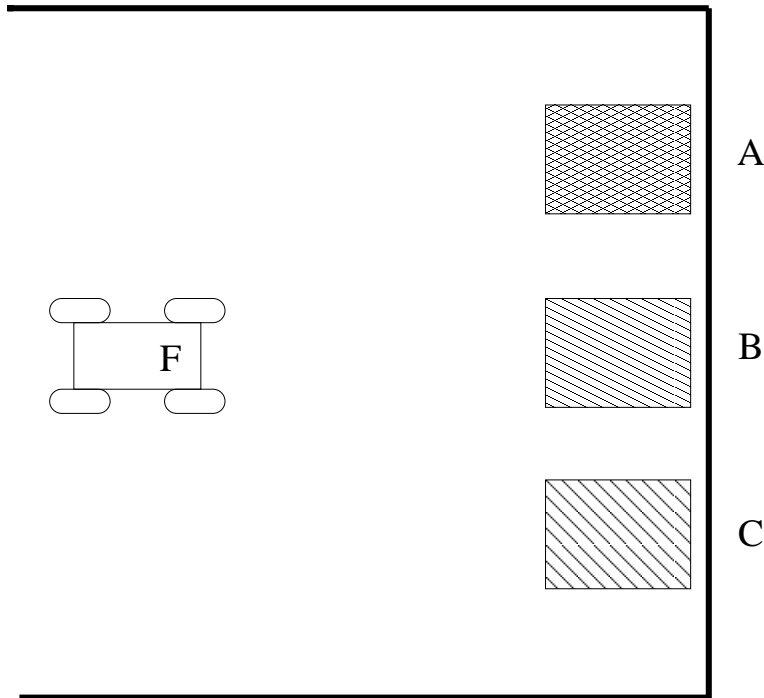
12. (6 points) If  $V_1 = 1V$  and  $V_3 = 0V$ , what is  $V_2$ ?  
 A. 0 V    B. 0.5 V    C. 0.75 V    D. 1 V    E. Answer not shown
13. (6 points) If  $V_1 = 2V$  and  $V_3 = 2V$ , what is  $I_D$ ?  
 A.  $-6.67 \text{ mA}$     B. 0 mA    C. 6.67 mA    D. 13.33 mA    E. Answer not shown

Part III. Digital/Analog Systems

14. (6 points) Assume a 3-bit analog-to-digital converter that uses the successive approximation algorithm, and has a range of 0 to 14 volts. What is the binary value that corresponds to  $V_{in} = 4.2 V$ ?
- A. 0001    **B. 0010**    C. 0011    D. 0111  
E. Answer not shown
15. (6 points) Assume an 4-bit analog-to-digital converter that uses the successive approximation algorithm, and has a range of 0 to 5 volts. If  $V_{in} = 3.2 V$  and the first guess by successive approximation is 1000, what is the third guess?
- A. 0010    B. 1000    C. 1100    **D. 1010**    E. Answer not shown
16. (6 points) Assume an 2-bit digital-to-analog converter that has a range of 0 to 3.3 V. What is the resolution of this converter (i.e., how much does the voltage change with one increment of the digital value)?
- A. 0.55 V    **B. 1.1 V**    C. 2.2 V    D. 3.3 V    E. Answer not shown

#### Part IV. Finite State Machines

Consider the following downward view of a field with a wheeled robot. The robot is initially facing to the right. Walls are indicated as thick lines. Three color pads are labeled *A*, *B*, and *C*. These pads can be colored green, purple or yellow.



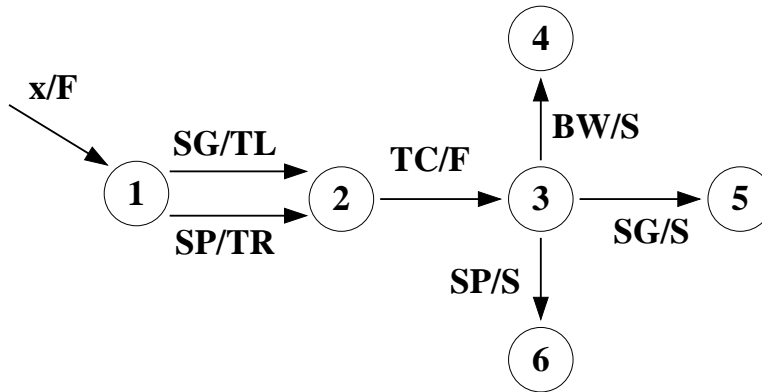
The possible actions include:

- Initiate a forward movement (F)
- Initiate a 90 degree turn to the left (L)
- Initiate a 90 degree turn to the right (R)
- Stop (S)

The possible events include:

- Bump wall (BW)
- Turn complete (TC)
- See Green directly below (SG)
- See Purple directly below (SP)

Now consider the following FSM:

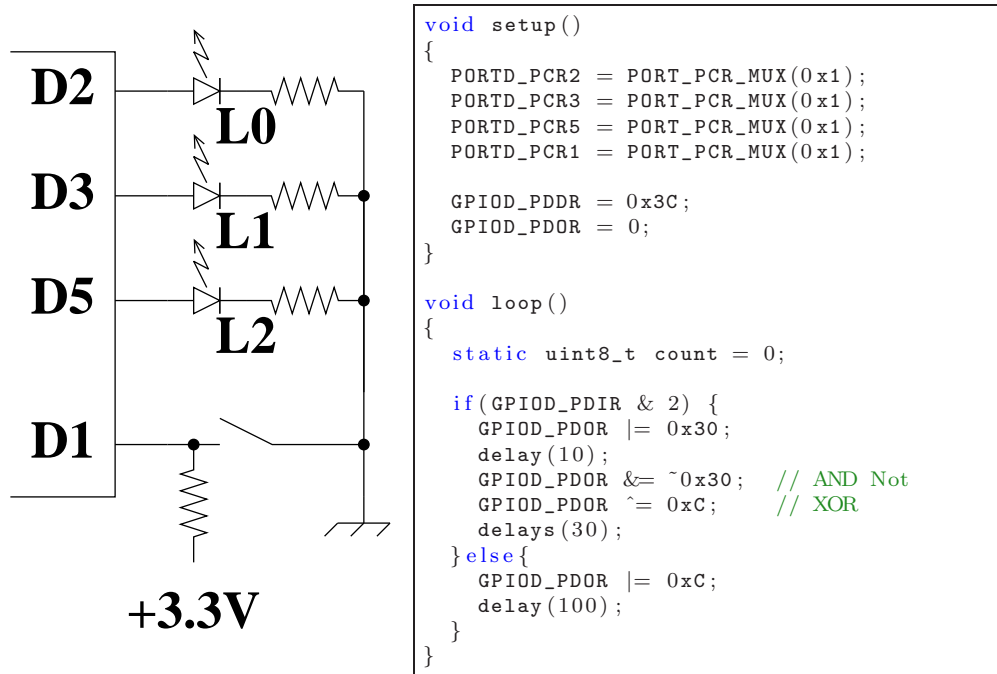


17. (4 points) When A = Purple; B = Purple; C = Purple, which state is the last to be visited?  
 A. 1    B. 4    C. 5    **D. 6**    E. Answer not shown
  
18. (4 points) When A = Green; B = Green; C = Purple, which state is the last to be visited?  
 A. 1    B. 4    **C. 5**    D. 6    E. Answer not shown
  
19. (4 points) When A = Yellow; B = Green; C = Yellow, which state is the last to be visited?  
 A. 1    **B. 4**    C. 5    D. 6    E. Answer not shown
  
20. (5 points) When A = Green; B = Yellow; C = Purple, which state is the last to be visited?  
**A. 1**    B. 4    C. 5    D. 6    E. Answer not shown



Part V. Digital I/O

Consider the following circuit and code:



21. (6 points) When the switch is closed, what is the flashing frequency of L1?  
 A. 5 Hz    B. 10 Hz    C. 12.5 Hz    D. 25 Hz    **E. The LED does not flash**
  
22. (6 points) When the switch is open, what is the duty cycle of L1?  
 A. 25%    B. 33.33%    **C. 50%**    D. 75%    E. The LED does not flash
  
23. (6 points) When the switch is open, what is the flashing frequency of L2?  
 A. 5 Hz    B. 10 Hz    C. 12.5 Hz    **D. 25 Hz**    E. The LED does not flash
  
24. (6 points) When the switch is open, what is the flashing frequency of L1?  
 A. 5 Hz    B. 10 Hz    **C. 12.5 Hz**    D. 25 Hz    E. The LED does not flash

## Part VI. Serial Processing

Consider the following code block:

```
1 int get_binary ()
2 {
3     char c;
4     uint8_t flag = 1;
5     uint16_t value = 0;
6
7     while(flag == 1)
8     {
9         c = Serial.read();
10        if(c >= '0' && c <= '1')
11        {
12            value = value * 10
13                + c - '0';
14        }
15        else
16        {
17            flag = 0;
18        }
19    }
20    return value;
21 }
```

25. (6 points) The above function is to interpret a sequence of zeros and ones as a binary number and return the corresponding value. It will continue to accept digits until a non-binary character is received.
- For example: '1', '0', '1', ' ' will result in the value 5 being returned. And the sequence '1', '1', ' ' will result in the value 3 being returned.
- On which line is the bug?
- A. 10    **B. 12**    C. 13    D. 17    E. There is no bug
26. (4 points) How many clocks are required for an asynchronous serial protocol?
- A. 0    B. 1    **C. 2**
27. (4 points) How many clocks are required for a synchronous serial protocol?
- A. 0    **B. 1**    C. 2