ECE 376 - Test #3: Name _____

Spring 2025. Open-Book, Open Note.

1) Edge Interrupts: Write a C program which uses edge interrupts for a game show:

- When button C is pressed, the lights on PORTC and PORTD are turned off in the main loop
- When button A is pressed,
  - If PORTD is off, the lights on PORTC turn on (A buzzed in first)
  - If PORTD is on, the lights on PORTC remain off
- When button B is pressed,
  - If PORTC is off, the lights on PORTD turn on (B buzzed in first)
  - If PORTC is on, the lights on PORTD remain off

Specify the interrupts used and their initialization.

Button C pin used	Button A Pin Used, Interrupt Used, Set-Up (rising/falling0	Button B Pin Used, Interrupt Used, Set-Up (rising/falling0
RB7	RB0 INT0 Rising Edge	RB1 INT1 Rising Edge

Specify the interrupt service routines (or main routine if using that for Button C)

Main Loop	Button A interrupt	Button B interrupt

`while(1) {`
`  if(RB7) {`
`  PORTC = 0;`
`  PORTD = 0;`
`  }`
`  }`
	`if(INT0IF) {`
	`  if(PORTD == 0)`
	`  PORTC = 0xFF;`
	`  else`
	`  PORTC = 0;`
	
	`  INT0IF = 0;`
	`  }`
		`if(INT1IF) {`
		`  if(PORTC == 0)`
		`  PORTD = 0xFF;`
		`  else`
		`  PORTD = 0;`
		
		`  INT1IF = 0;`
		`  }`

2) Timer Interrupts: Write a C program which uses timer interrupts for a game show:

- Timer2 is set up to interrupt every N clocks
  - N = 10,000 + 1000 * birth month (1..12) + 100 * birthday (1..31)
  - Example: May 12th would result in N = 10,000 + 5*1000 + 12*100 = 16,200
- Every Timer2 interrupt, it checks three buttons
  - Player A: RB0
  - Player B: RB1
  - Reset: RB7
- If RB7 is pressed lights on PORTC and PORTD are turned off
- If RB0 is pressed (player A)
  - If PORTD is off, the lights on PORTC are turned on (A buzzed in first)
  - Otherwise, the lights on PORTC remain off
- If RB1 is pressed (player B)
  - If PORTC is off, the lights on PORTD are turned on (B buzzed in first)
  - Otherwise the lights on PORTD remain off

Intialization: Specify A/B/C for Timer2

N # clocks between interrupts 10,000 + 1000 * birth month + 100 * birth day	A, B, C Timer2 Initialization
N = 16,200	A = 4 C = 16 B = 253

Specify the main routine and the Timer2 interrupt service routine

Main Routine	Timer2 Interrupt Service Routine

```
while(1) {
   }
```

```
if(TMR2IF) {
   if(RB7) {
      PORTC = 0;
      PORTD = 0;
      }
   if(RB0) {
      if(PORTD == 0)
         PORTC = 0xFF;
      else
         PORTC = 0;
      }
   if(RB1) {
      if(PORTC == 0)
         PORTD = 0xFF;
      else
         PORTD = 0;
      }
   TMR2IF = 0;
   }
```

3) Capture Interrupts: Use Timer1 Capture interrupts for a game show.

- When button C is pressed,
  - PORTC and PORTD are turned off and
  - A's time and B's time are set to zero (default)
- When button A is pressed,
  - The time buton A was pressed is recorded as a 32-bit time accurate to 100ns (one clock)
  - If A's time is less than B's time, the lights on PORTC are turned on (A buzzed in first)
  - If A's time is more than B's time, the lights on PORTC remain off
- When button B is pressed,
  - The time button B was pressed is recorded as a 32-bit time accurate to 100ns (one clock)
  - If B's time is less than A's time, the lights on PORTD are turned on (B buzzed in first)
  - If B's time is more than A's time, the lights on PORTD remain off

Specify the initialization for each interrupt used

Timer1 pre-scalar	Capture 1 rising / falling / 4th rising / 16h rising	Capture 2 rising / falling / 4th rising / 16h rising
1	Rising Every edge	Rising Every Edge

Specify the main routine and the interrupt service routines

Main Loop	Timer1	Capture 1 & Capture 2

`while(1) {`
`  if(RB7) {`
`  PORTC = 0;`
`  PORTD = 0;`
`  A = 0;`
`  B = 0;`
`  }`
`  }`
	`if (TMR1IF) {`
	`  TIME += 0x10000;`
	`  TMR1IF = 0;`
	`  }`
		`// both buttons pressed within 50 clocks`
		`if (CCP1IF)`
		`  if(A == 0) A = TIME + CCPR1;`
		`if (CCP2IF)`
		`  if(B == 0) B = TIME + CCPR2;`
		
		`// see who won`
		`if(CCP1IF) {`
		`  if( (B == 0) | (A < B) ) {`
		`  PORTC = 0xFF;`
		`  PORTD = 0;`
		`  }`
		`  CCP1IF = 0;`
		`  }`
		`if(CCP2IF) {`
		`  if( (A == 0) | (B < A) ) {`
		`  PORTC = 0;`
		`  PORTD = 0xFF;`
		`  }`
		`  CCP2IF = 0;`
		`  }`
		
		notes:
		
		On a tie (A == B), neither light turns on

4) Digital Filter Design: Assume X and Y are related by the following transfer function:

$$Y = \left(\frac{7(s+40)}{(s+2)(s+D)(s+M)}\right)X = G(s)\cdot X$$

where D is your birthday (1..31) and M is your birth month (1..12). Give the transfer function of a digital filter which has the same time & frequency response as G(s).

- Assume a sampling rate of 15ms (T = 0.015)

M = 12

D = 14

$$G(s) = \left(\frac{7(s+40)}{(s+2)(s+12)(s+14)}\right)X$$

Convert the poles and zeros

$$s = -40 \qquad z = e^{sT} = 0.5488$$

$$s = -2 \qquad z = e^{sT} = 0.9704$$

$$s = -12 \qquad z = e^{sT} = 0.8353$$

$$s = -14 \qquad z = e^{sT} = 0.8106$$

so

$$G(z) = \left(\frac{k(z-0.5488)}{(z-0.9704)(z-0.8353)(z-0.8106)}\right)$$

At DC (s = 0)

$$\left(\frac{7(s+40)}{(s+2)(s+12)(s+14)}\right)_{s=0} = 0.7143$$

Match the DC gain

$$\left(\frac{k(z-0.5488)}{(z-0.9704)(z-0.8353)(z-0.8106)}\right)_{z=1} = 0.7143$$

$$k = 0.0017$$

so

$$G(z) = \left(\frac{0.0017(z-0.5488)}{(z-0.9704)(z-0.8353)(z-0.8106)}\right)$$