1) Given the C program program for serial communication. Answer the questions for parts a and b below.

```
#include <avr/io.h>

unsigned char cleared = 1<<UDRE;

int main()
{
        int i;
        DDRD = 0b00000010;
        PORTD = 0xFF;
        UCSRB = (1<<RXEN) | (1<<TXEN);
        UCSRC = (1<<UCSZ1) | (1<<UCSZ0) | (1<<URSEL);
        UBRRL = 0x33;
        while(1)
        {
                while(!(UCSRA & cleared));
                UDR = 'G';
        }

        return 0;
}
```

a. Is serial transmission or reception or both modes enabled? Which serial operation(s) is(are) performed in the program (transmission/reception/both)? Circle the program instruction(s) that you used to determine your answer.
b. Is polling or an interrupt used in this program for serial communication? Circle the program instruction(s) that you used to determine your answer.

2) Below is a C program that outputs square waves using Timers 0 and 2. Create a Microchip Studio workspace (GCC C Executable Project for the ATmega32) and copy the C code into the C workspace. Answer the questions for parts a-e on the following page.

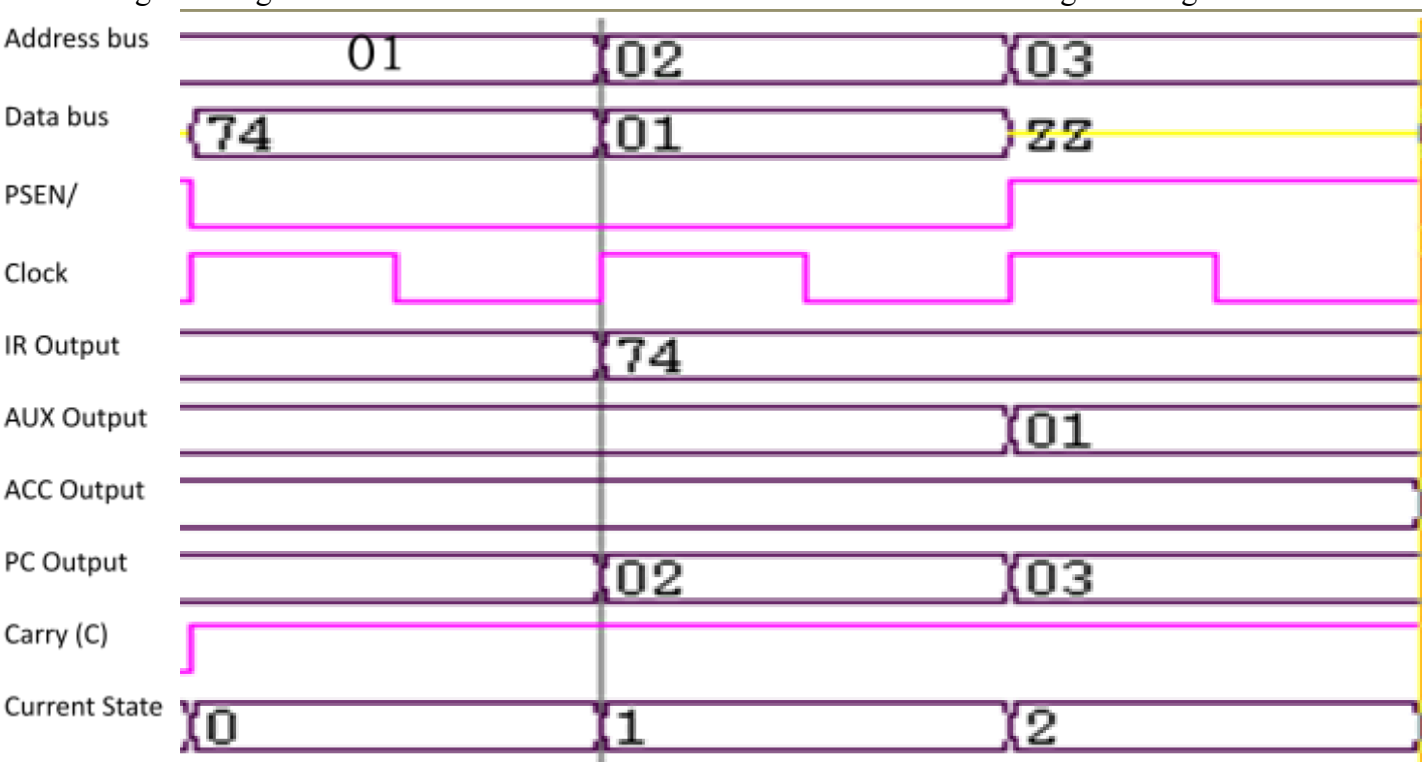
```
#include <AVR/IO.H>
#include <AVR/INTERRUPT.H>

ISR(TIMER0_OVF_vect);
ISR(TIMER2_OVF_vect);


int main()
{
        DDRB |= 0B01100000;
        TIMSK = (1<<TOIE0) | (1<<TOIE2);
        TCNT0 = -30;
        TCNT2 = -60;
        TCCR0 = 0X05;
        TCCR2 = 0x02;
```

```
        sei();
        while(1);
        return 1;
}

ISR(TIMER0_OVF_vect)
{
        TCNT0 = -30;
        PORTB ^= 0X40;
}

ISR(TIMER2_OVF_vect)
{
        TCNT2 = -60;
        PORTB ^= 0X20;
}
```

a) From the Disassembly window of the workspace, identify the interrupt code for the interrupt routines for Timers 0 and 2. Submit a screenshot of showing the C/assembly code for both interrupt service routines.

b) Describe differences between the C and Assembly code implementations for the waveforms generated using Timers 0 and 2 (excluding version of the program is in C and the translated version is in assembly). Is the assembly code an efficient translation of the C code? Explain.

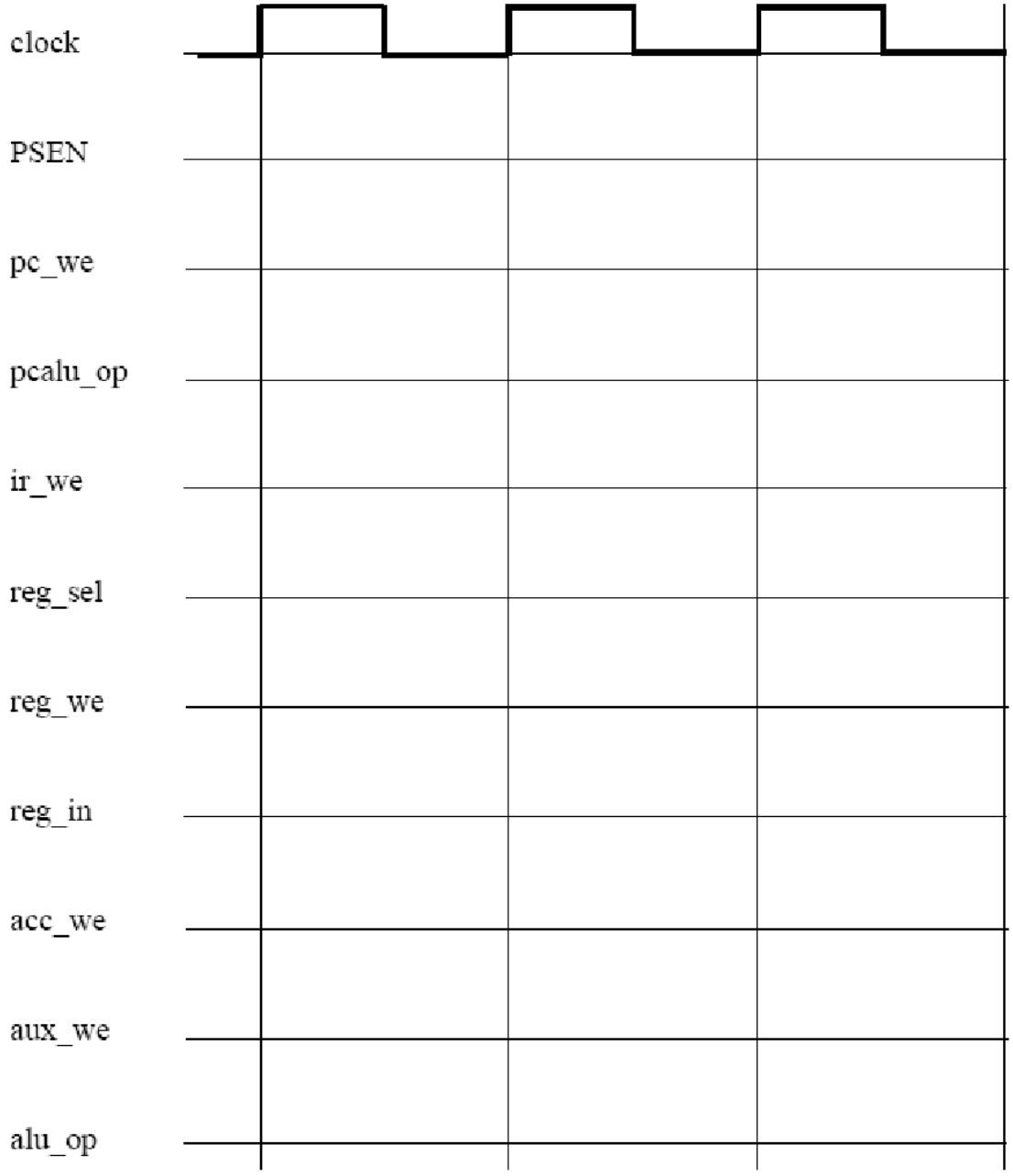
3) Given the following timing signals for the WIMP51 for an instruction cycle. For the Current State signal, note that 0 = fetch state, 1 = decode state, 2 = execute state. The instruction set and architecture diagram are given below. The WIMP51 instruction set and architecture diagram are given below.



Determine the instruction being executed during the instruction cycle.

4) Draw the timing diagram for the following control signals on the diagram below when the WIMP51 is executing the instruction ___MOV A, R5_____. Label the fetch, decode and execute parts of the instruction cycle on the clock portion of the signal below.

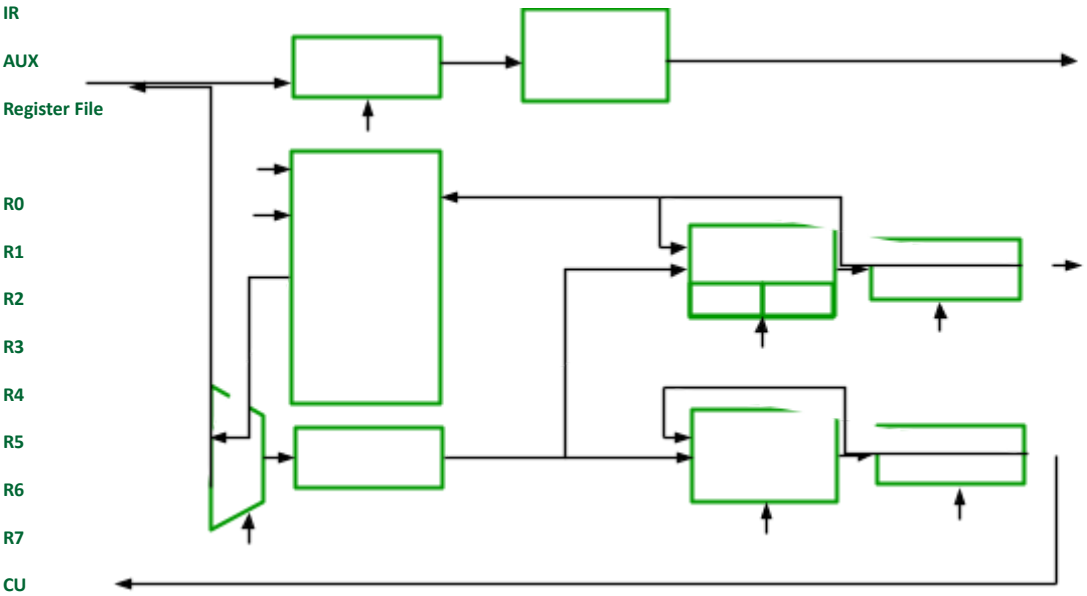
The dotted lines have been drawn as a graphical reference only and do not reflect the value of the corresponding signal. If you think a particular control signal is of no significance during a particular time period, indicate this opinion by using a **dashed** line to denote the signal as a "don't care" for that time period. Give "command" values for pcalu_op and alu_op; for example, indicate the value of "pcalu_op" as "PC_INC" or "PC_ADD" rather than representing this command by a numeric code. If you are not sure about a particular control signal, make an educated guess, indicate that the value you have marked is a guess, and explain why you made this particular guess. Remember, PSEN/ pulses low whenever a byte is being fetched from code memory.



Summary of WIMP51 Inst Set

ASM code	Machine code	Meaning
MOV A, #D	01110100 dddddddd	A<=D
ADDC A,#D	00110100 dddddddd	C,A<=A+D+C
MOV Rn, A	11111nnn	Rn<=A
MOV A, Rn	11101nnn	A<=Rn
ADDC A, Rn	00111nnn	C,A<=A+Rn+C
ORL A, Rn	01001nnn	A<=A OR Rn
ANL A, Rn	01011nnn	A<= A AND Rn
XRL A, Rn	01101nnn	A<=A XOR Rn
SWAP A	11000100	$A<=A_{(3-0)}\&A_{(7-4)}$
CLR C	11000011	C<=0
SETB C	11010011	C<=1
SJMP rel	10000000 aaaaaaaa	PC<=PC+rel+2
JZ rel	01100000 aaaaaaaa	PC<=PC+rel+2 if Z=1

WIMP51 Architecture Diagram



pcalu_op

acc_we

pc_we

aux_we

reg_in

ir_we

reg_we

reg_sel

reg_sel

0

1

acc_out

PSEN

5) Chapter 11: 7, 15, 30, 34 a,c, 36-polling method (no interrupts), 36-use serial interrupts (XTAL = 10 MHz)
   Problems are below.

SECTION 11.1: BASICS OF SERIAL COMMUNICATION

1. Which is more expensive, parallel or serial data transfer?
2. True or false. 0- and 5-V digital pulses can be transferred on the telephone without being converted (modulated).
3. Show the framing of the letter ASCII 'Z' (0101 1010), no parity, 1 stop bit.
4. If there is no data transfer and the line is high, it is called _____ (mark, space).
5. True or false. The stop bit can be 1, 2, or none at all.
6. Calculate the overhead percentage if the data size is 7, 1 stop bit, and no parity bit.
7. True or false. The RS232 voltage specification is TTL compatible.
8. What is the function of the MAX 232 chip?
9. True or false. DB-25 and DB-9 are pin compatible for the first 9 pins.
10. How many pins of the RS232 are used by the IBM serial cable, and why?
11. True or false. The longer the cable, the higher the data transfer baud rate.
12. State the absolute minimum number of signals needed to transfer data between two PCs connected serially. What are those signals?
13. If two PCs are connected through the RS232 without a modem, both are configured as a _____ (DTE, DCE) -to- _____ (DTE, DCE) connection.

14. State the nine most important signals of the RS232.
15. Calculate the total number of bits transferred if 200 pages of ASCII data are sent using asynchronous serial data transfer. Assume a data size of 8 bits, 1 stop bit, and no parity. Assume each page has 80 × 25 of text characters.
16. In Problem 15, how long will the data transfer take if the baud rate is 9600?

29. Which of the following baud rates are supported by the HyperTerminal program in PC?
    (a) 4800 (b) 3600 (c) 9600
    (d) 1800 (e) 1200 (f) 19,200
30. Which register of ATmega32 is used for baud rate programming?
31. Which bit of the UCSRA is used for baud rate speed?
32. What is the role of the UDR register in serial data transfer?
33. UDR is a(n) ____-bit register.
34. For XTAL = 10 MHz, find the UBRR value (in both decimal and hex) for each of the following baud rates.
    (a) 9600 (b) 4800 (c) 1200
35. What is the baud rate if we use UBRR = 15 to program the baud rate? Assume XTAL = 10 MHz.
36. Write an AVR program to transfer serially the letter 'Z' continuously at 9600 baud rate. Assume XTAL = 10 MHz.
37. When is the PE flag bit raised?
38. When is the RXC flag bit raised or cleared?
39. When is the UDRE flag bit raised or cleared?
40. To which register do RXC and UDRE belong?
41. Find the UBRR for the following baud rates if XTAL = 16 MHz and U2X = 0.

    (a) 9600 (b) 19200
    (c) 38400 (d) 57600
42. Find the UBRR for the following baud rates if XTAL = 16 MHz and U2X = 1.
    (a) 9600 (b) 19200
    (c) 38400 (d) 57600

SECTION 11.4: AVR SERIAL PORT PROGRAMMING IN C

49. Write an AVR C program to transmit serially the letter 'Z' continuously at 9600 baud rate.
50. Write an AVR C program to transmit serially the message "The earth is but one country and mankind its citizens" continuously at 57,600 baud rate.