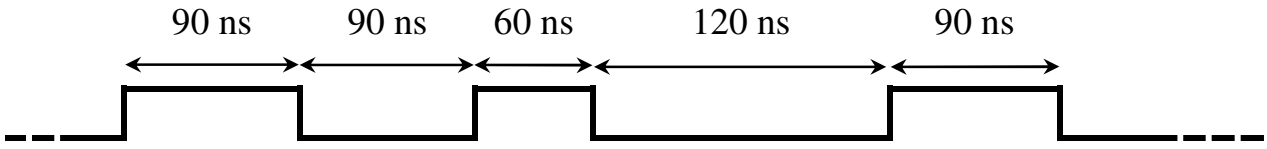
1) Assemble by hand the following subroutine for the CV-8052 processor. Use the opcodes provided in the appendices at the end of this exam. (10 marks)

Address	Opcode/Operands	Instruction
		`dseg at 30H`
		`bcd:  ds 5`
		`x:  ds 4`
		`cseg at 1000H`
		`h2b:  clr a`
		`mov bcd+0, a`
		`mov bcd+1, a`
		`mov bcd+2, a`
		`mov bcd+3, a`
		`mov bcd+4, a`
		`mov r2, #32`
		`h2b_L0: mov r1, #4`
		`mov r0, #(x+0)`
		`h2b_L1: mov a, @r0`
		`rlc a`
		`mov @r0, a`
		`inc r0`
		`djnz r1, h2b_L1`
		`mov r1, #5`
		`mov r0, #(bcd+0)`
		`h2b_L2: mov a, @r0`
		`addc a, @r0`
		`da a`
		`mov @r0, a`
		`inc r0`
		`djnz r1, h2b_L2`
		`djnz r2, h2b_L0`
		`ret`

2) Disassemble the following sequence of machine code for the 8051 microcontroller. All the numbers are in hexadecimal. Use the tables of opcodes provided in the appendices at the end of this exam. (10 marks)

C0 D0 C0 E0 C0 00 E9 29 24 32 F8 D8 FE D0 00 D0 E0 D0 D0 22

3) Write a subroutine to generate the signal shown below at pin P0.0 of a CV-8052 processor running at 33.333333 MHz. The CV-8052 takes one clock period per machine cycle. Assume the pin is configured as an output, and that the signal is already set to logic zero before the subroutine is called. Use the cycles per instruction in the tables provided at the end of this exam. (10 marks)

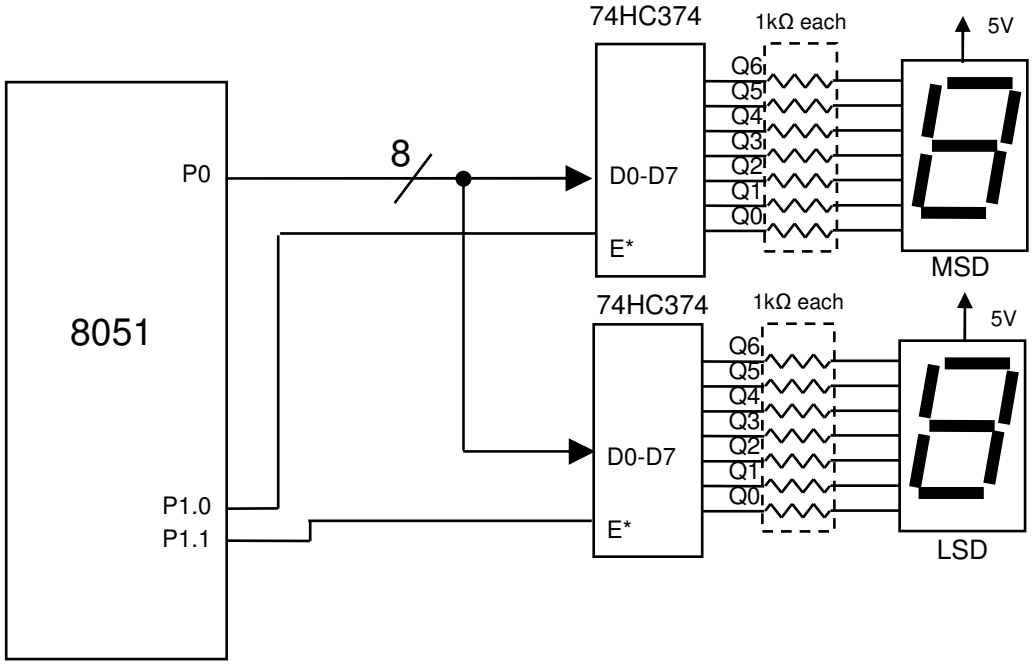


4) Write an assembly subroutine for the 8051 microcontroller to perform the operation Z=X−Y, where Z, X, and Y are packed **BCD** numbers defined as:

```
     DSEG at 040H
X:   DS 3 ; six BCD digits for input X
Y:   DS 3 ; six BCD digits for input Y
     XSEG at 4000H
Z:   DS 3 ; six BCD digits for result Z
```

Assume the least significant **BCD** digits are stored at the lowest memory location for all the variables. Tip: X−Y =X + nine_complement(Y) + 1. (15 marks)

5) A little league baseball scoreboard includes the circuit shown in the figure below to count the number of pitches the current pitcher has thrown. Write an 8051 assembly subroutine to increment the number of pitches stored in register B (in BCD) and display the result using the common-anode 7-segment displays wired as shown in the circuit. (10 marks)




```
Dec7Seg:
    DB 40H, 79H, 24H, 30H, 19H, 12H, 02H, 78H, 00H, 10H
```

6) The two look-up tables below can be used to quickly convert a register to its hexadecimal ASCII representation. Write an assembly subroutine for the 8051 microcontroller to convert the value passed in register B to its hexadecimal ASCII representation and store the two ASCII values into registers R6 and R7 where R6 is the least significant digit. If variable UPPER is set to '1' use upper case letters. Otherwise use lower case letters. (10 marks)

```
BSEG
UPPER: DBIT 1

CSEG
TO_HEX_UPPER: DB '0123456789ABCDEF'
TO_HEX_LOWER: DB '0123456789abcdef'
```

7) The 8051 assembly subroutine below configures timer/counter 0 as a 16-bit counter. Write an Interrupt Service Routine for counter 0 that:

a) Increments a 16-bit variable defined in the ISEG called 'ovf_count'. Assume the variable is located in memory above address 0x7F.
b) Preserves the value of all the used registers.
c) Returns properly.

Note: the vector address for counter 0 interrupt is 000BH. (15 marks)

```
Init_counter_0:
    clr EA          ; Disable interrupts
    clr TR0         ; Stop counter 0
    mov TMOD, #05H ; Configure counter 0 in mode 1
    clr TF0         ; Clear overflow flag
    mov TH0, #0
    mov TL0, #0
    clr a
    mov R0, #ovf_count
    mov @R0, a      ; Clear overflow counter low
    inc R0
    mov @R0, a      ; Clear overflow counter high
    setb TR0        ; Start counter 0
    setb ET0        ; Enable counter 0 overflow interrupt
    setb EA         ; Enable global interrupts
    ret
```

8) The circuit in the figure below can be used to verify that a 74HC86 integrated circuit (IC) operates correctly. The 74HC86 IC consists of four 2-input XOR gates. Write a subroutine for the CV-8052 processor that tests the IC after push button PB1 is pressed and then released. Additionally, the subroutine should: configure the input and output pins, apply power to the IC, test all possible input/output combinations and either turn the green LED on if the IC passes all the tests or the red LED on if the IC fails any test. The subroutine should set the power pin as well as all of the IC inputs to zero before returning so that the IC can be removed safely from the circuit after the tests are completed. TIP: you can test all four gates at once! (20 marks)