1. Given the following PIC18 assembler listing, show the final contents of the Stack and Stack Pointer after the execution of the third subroutine call.

```
-----------------------------------------
PIC ASSEMBLER LISTING
Address Opcode  Instruction
-----------------------------------------

000084  EC51    START:    CALL      UNPACK
000086  F000
000088  EC59              CALL      OUTLED
00008A  F000
00008C  0E05              MOVLW     D'5'


0000A2  5000    UNPACK:   MOVF      COUNTER,W
0000A4  0B0F              ANDLW     0x0F

0000AE  3A02              SWAPF     BCD1,F
0000B0  0012              RETURN


0000B2  5001    OUTLED:   MOVF      BCD0,W
0000B4  EC64              CALL      GETCODE
0000B6  F000
0000B8  CFF5              MOVFF     TABLAT,PORTC


0000C8  6E03    GETCODE:  MOVWF     TEMP
0000CA  0E00              MOVLW     UPPER LEDCODE
```

2. Modify the BCDBIN subroutine (IP8-1) to use a separate subroutine UNPACK.

a) Draw flowcharts for the subroutines (and indicate any registers used).
b) Write the assembly language for the subroutines and simulate using sample data.
c) Your solution should include the assembler listing and an annotated screen capture of the simulator showing the final register values.

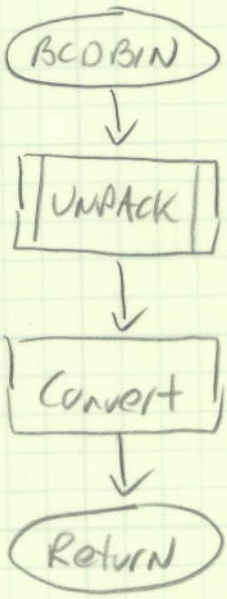
(1) Stack Pointer

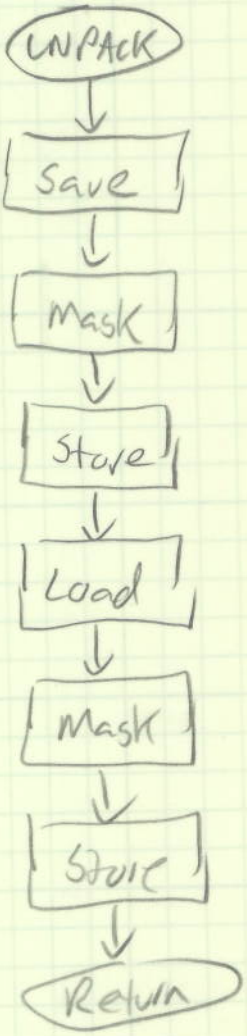
0X0X2

STACK

//////	0
~~0088~~ 008C	1
00B8	2
	3

(2) BCDBIN w/ Subroutine UNPACK





BCD# | 37 | WREG

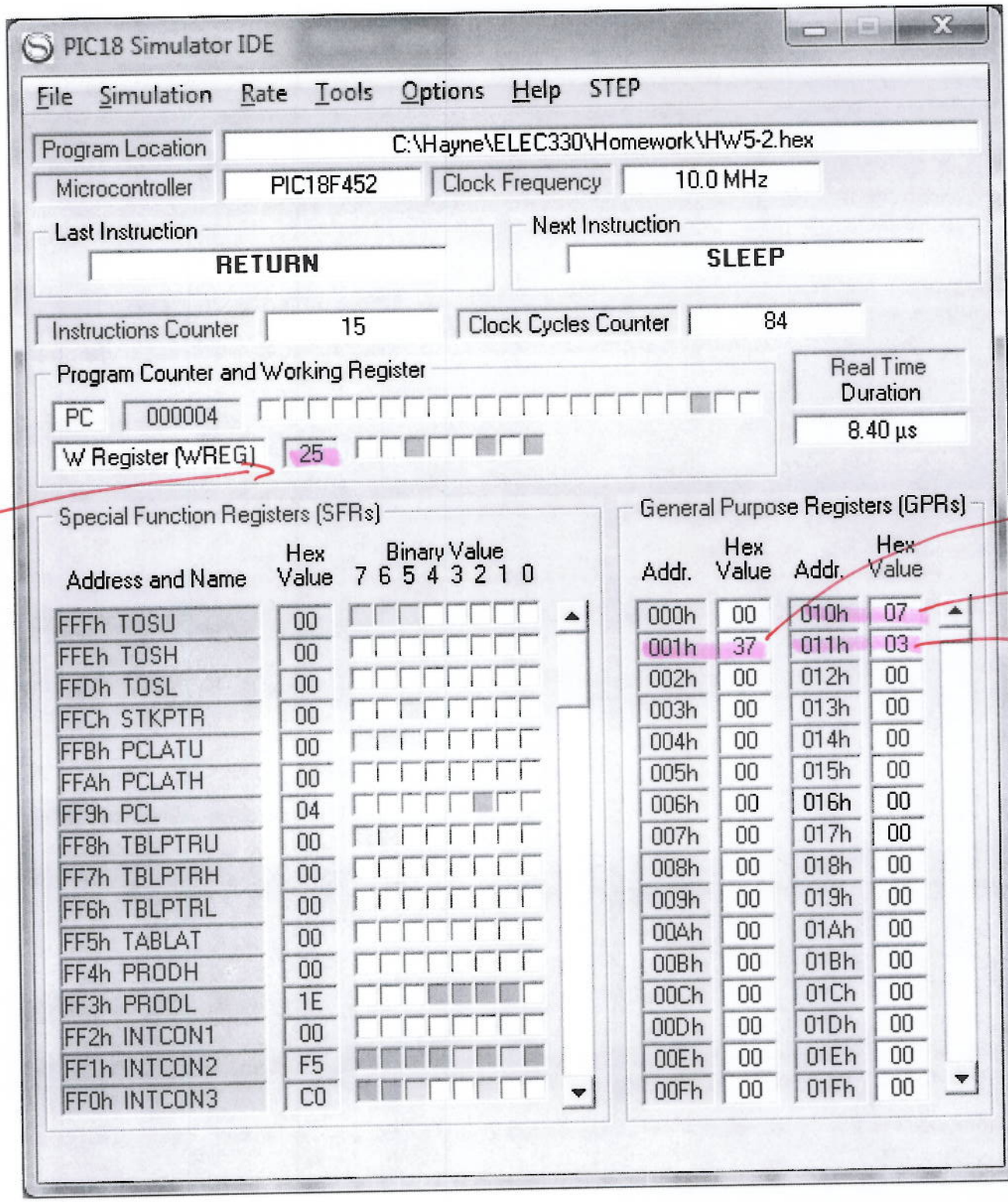
3	BCD1
7	BCD0

Bin# | D'37' | WREG

0x25

Temp | 37 | REG1

```
-------------------------------------------------
PIC ASSEMBLER LISTING
Line   Address Opcode  Instruction
-------------------------------------------------
0001   000000          ;::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
0002   000000          ;Function: BCDBIN subroutine converts a two-digit BCD number into it binar
0003   000000          ; Input:   Two-digit BCD number in WREG
0004   000000          ; Output:  Binary equivalent of the BCD number in WREG
0005   000000          ; Calls subroutine: UNPACK
0006   000000          ;::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
0007   000000
0008   000000          ;Line removed by MPASMWIN preprocessor:          Title "HW5-2 BCD to Binary
0009   000000
0010   000000          ;Line removed by MPASMWIN preprocessor:          List p=18F452, f =inhx32
0011   000000          ;Line removed by MPASMWIN preprocessor:          #include <p18F452.inc>   ;T
0012   000000
0013   000000          BCD0     EQU    0x10               ;Define data register addresses
0014   000000          BCD1     EQU    0x11
0015   000000          REG1     EQU    0x01
0016   000000
0017   000000                   ORG    0x00
0018   000000  EC10             CALL   BCDBIN
0018   000002  F000
0019   000004  0003             SLEEP
0020   000006
0021   000006                   ORG    0x20               ;Begin assembly at 0020H
0022   000020  EC18    BCDBIN:  CALL   UNPACK
0022   000022  F000
0023   000024  5011             MOVF   BCD1,W             ;Get high digit
0024   000026  0D0A             MULLW  D'10'              ;Multiply by 10
0025   000028  CFF3             MOVFF  PRODL,WREG         ;Move Product
0025   00002A  FFE8
0026   00002C  2410             ADDWF  BCD0,W             ;Add low digit
0027   00002E  0012             RETURN
0028   000030
0029   000030          ;::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
0030   000030          ;Function: UNPACK subroutine unpacks two-digit BCD number
0031   000030          ; Input:   Two-digit BCD number in WREG
0032   000030          ; Ouptut:  Two unpacked digits in BCD1(High) and BCD0(Low)
0033   000030          ;::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
0034   000030
0035   000030  6E01    UNPACK:  MOVWF  REG1               ;Save packed byte in REG1
0036   000032  0B0F             ANDLW  0x0F               ;Mask high-order nibble
0037   000034  6E10             MOVWF  BCD0               ;Store low-order nibble in BCD0
0038   000036  5001             MOVF   REG1,W             ;Get the byte again
0039   000038  38E8             SWAPF  WREG,W
0040   00003A  0B0F             ANDLW  0x0F               ;Mask low-order nibble
0041   00003C  6E11             MOVWF  BCD1               ;Sroew high-order nibble
0042   00003E  0012             RETURN
0043   000040
0044   000040                   END
-------------------------------------------------
Number of errors = 0
```


PIC18 Simulator IDE
File Simulation Rate Tools Options Help STEP
Program Location
C:\Hayne\ELEC330\Homework\HW5-2.hex
Microcontroller
PIC18F452
Clock Frequency
10.0 MHz
Last Instruction
RETURN
Next Instruction
SLEEP
Instructions Counter
15
Clock Cycles Counter
84
Program Counter and Working Register
PC
000004
W Register (WREG)
25
Real Time Duration
8.40 µs
Special Function Registers (SFRs)
Address and Name
Hex Value
Binary Value 7 6 5 4 3 2 1 0
FFFh TOSU 00
FFEh TOSH 00
FFDh TOSL 00
FFCh STKPTR 00
FFBh PCLATU 00
FFAh PCLATH 00
FF9h PCL 04
FF8h TBLPTRU 00
FF7h TBLPTRH 00
FF6h TBLPTRL 00
FF5h TABLAT 00
FF4h PRODH 00
FF3h PRODL 1E
FF2h INTCON1 00
FF1h INTCON2 F5
FF0h INTCON3 C0
General Purpose Registers (GPRs)
Addr. Hex Value Addr. Hex Value
000h 00 010h 07
001h 37 011h 03
002h 00 012h 00
003h 00 013h 00
004h 00 014h 00
005h 00 015h 00
006h 00 016h 00
007h 00 017h 00
008h 00 018h 00
009h 00 019h 00
00Ah 00 01Ah 00
00Bh 00 01Bh 00
00Ch 00 01Ch 00
00Dh 00 01Dh 00
00Eh 00 01Eh 00
00Fh 00 01Fh 00
Binary Result
Temp
BCD0
BCD1