EECE416 :Microcomputer Fundamentals and Design

source: www.mwftr.com

68000 Programming Techniques

with EASY68K

Programming Techniques

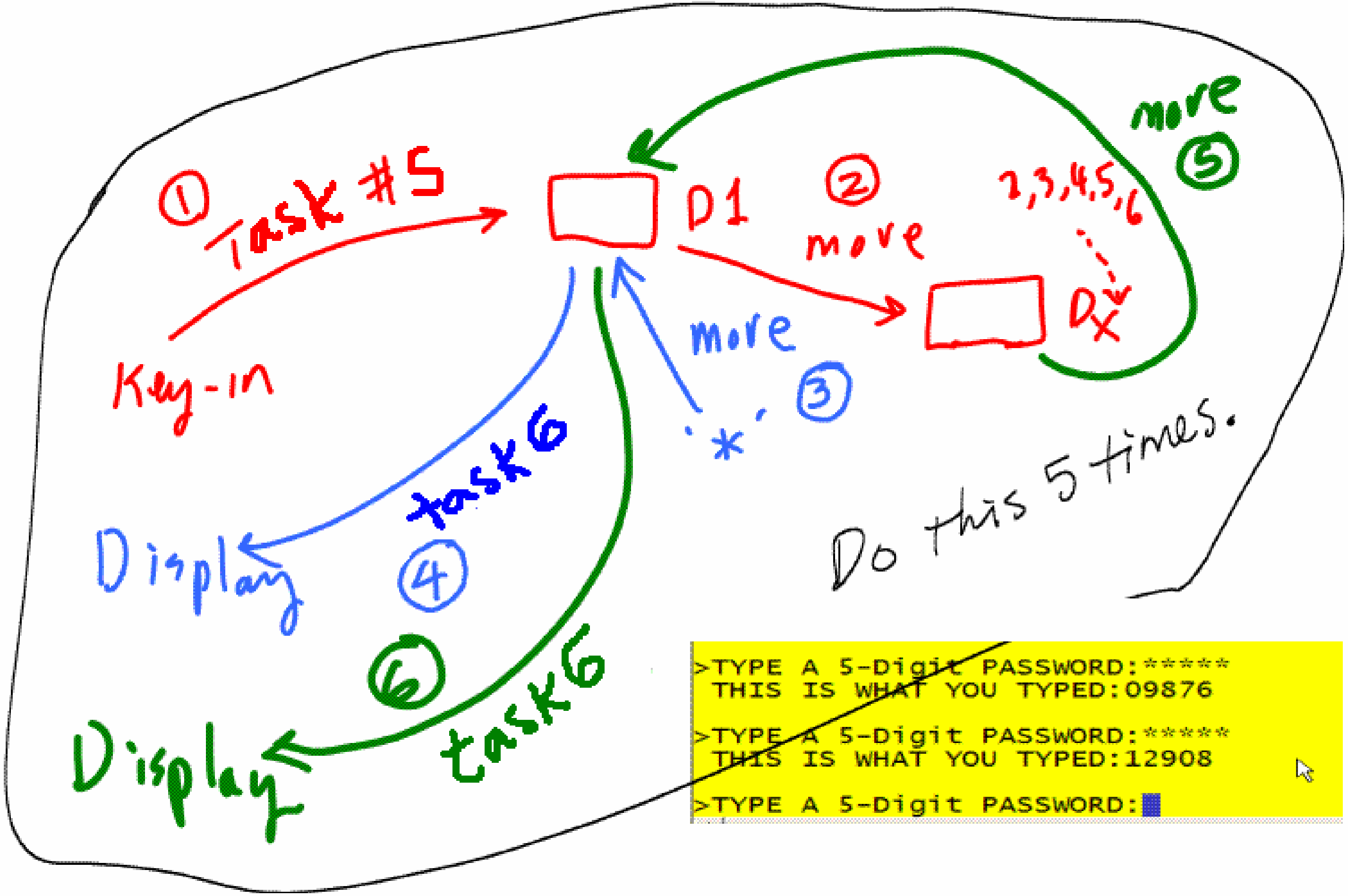
- Subroutines and Parameter Passing
- Data gathering
- Searching Data Table
- String Operations
- Sorting
- Computational Routines
- Number Conversion
- Examples

Exercise I

- TrapExample.x68
  - Using different TRAPs for Key-In and Display
    - Trap task 5
      - Read a character from keyboard
      - Stored the keyed-in in the D1.B
    - Trap task 6
      - Display a character stored in D1.B
    - Trap task 0 (with CR.LF)/1 (w/o CR.LF)
      - Display a string of characters whose starting address is stored in A1 register
      - Display of the string continues until it meets number 0 [zero]
    - Trap task12
      - Key echo-off (with D1.B=0)
      - Key echo-on (with D1.B=non zero value)
  - A character guessing game

Exercises (Password Echo)

- P-ECHO.x68
  - Accept 5-digit number, and display * for each digit
  - And display at the next line the password



```
>TYPE A 5-Digit PASSWORD:*****
 THIS IS WHAT YOU TYPED:09876

>TYPE A 5-Digit PASSWORD:*****
 THIS IS WHAT YOU TYPED:12908

>TYPE A 5-Digit PASSWORD:
```

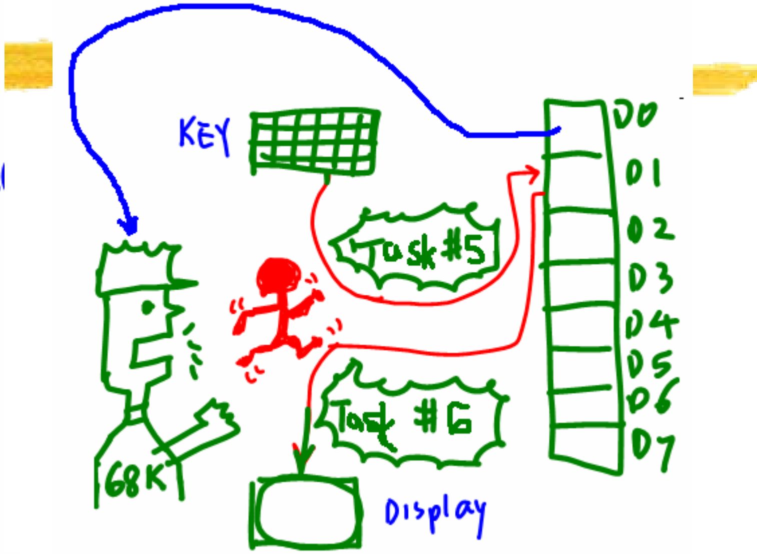
Tell me why we have to move around.

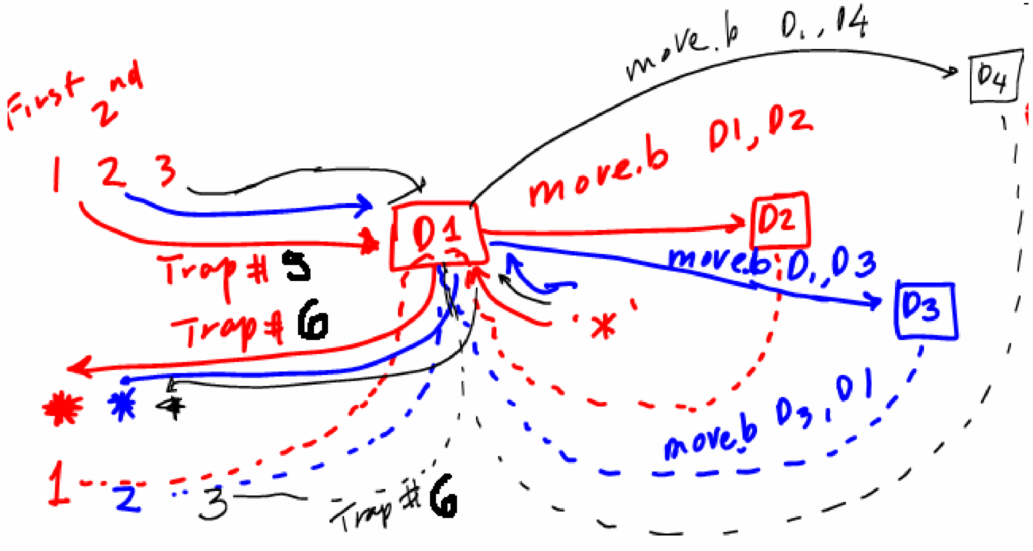
① Only D_1 is used as a receptionist:
Input and Output should pass through the receptionist.

② The Receptionist (D_1) handlles only 1 visitor (1 character). If you input 2 characters, only the latest one is registered and stored in D_1

③ Fortunately, there are 7 additional Rooms to Keep the visitors: $D_0, D_2, D_3, D_4, D_5, D_6, D_7$.

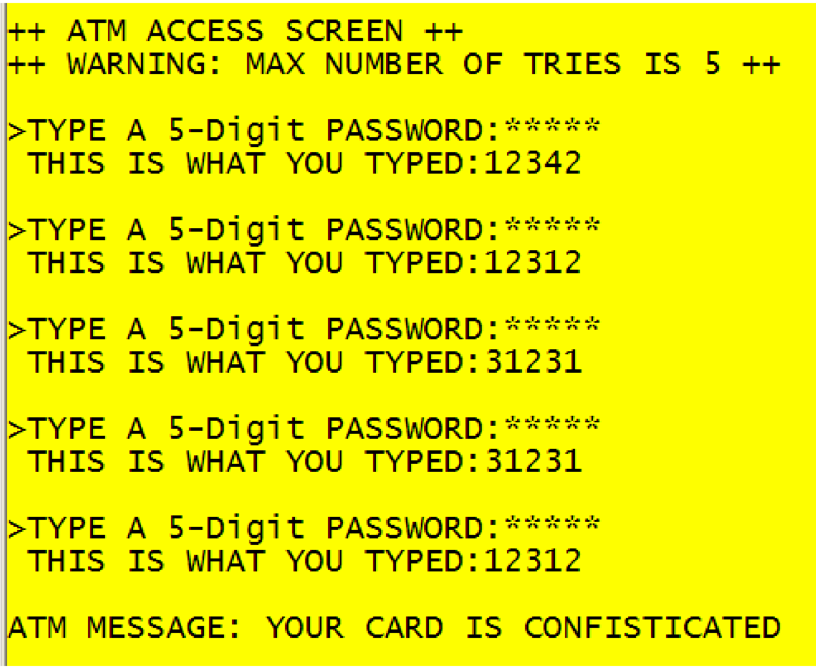
④ So, for multiple characters, they can be stayed (after registering with D1, receptionist) at one of the rooms.



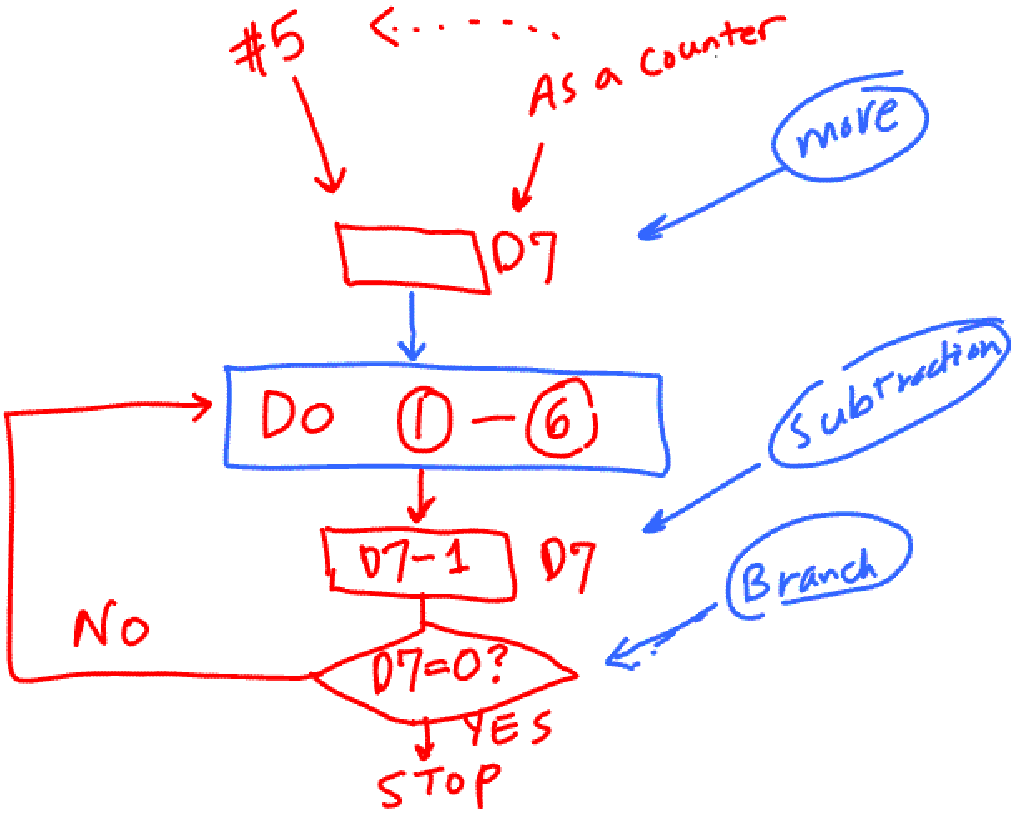


Exercises - continued

- Revision of P-ECHO.asm to C-ECHO.asm
  - Allow only 5 times of Password Tries for ATM access

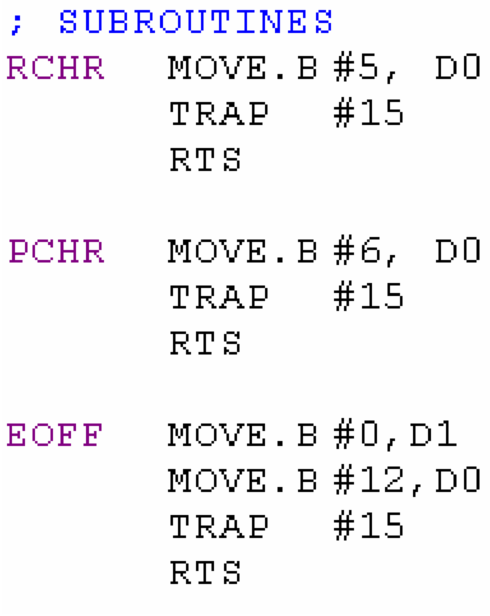


```
++ ATM ACCESS SCREEN ++
++ WARNING: MAX NUMBER OF TRIES IS 5 ++

>TYPE A 5-Digit PASSWORD:*****
 THIS IS WHAT YOU TYPED:12342

>TYPE A 5-Digit PASSWORD:*****
 THIS IS WHAT YOU TYPED:12312

>TYPE A 5-Digit PASSWORD:*****
 THIS IS WHAT YOU TYPED:31231

>TYPE A 5-Digit PASSWORD:*****
 THIS IS WHAT YOU TYPED:31231

>TYPE A 5-Digit PASSWORD:*****
 THIS IS WHAT YOU TYPED:12312

ATM MESSAGE: YOUR CARD IS CONFISTICATED
```



3 Subroutines for TRAP business

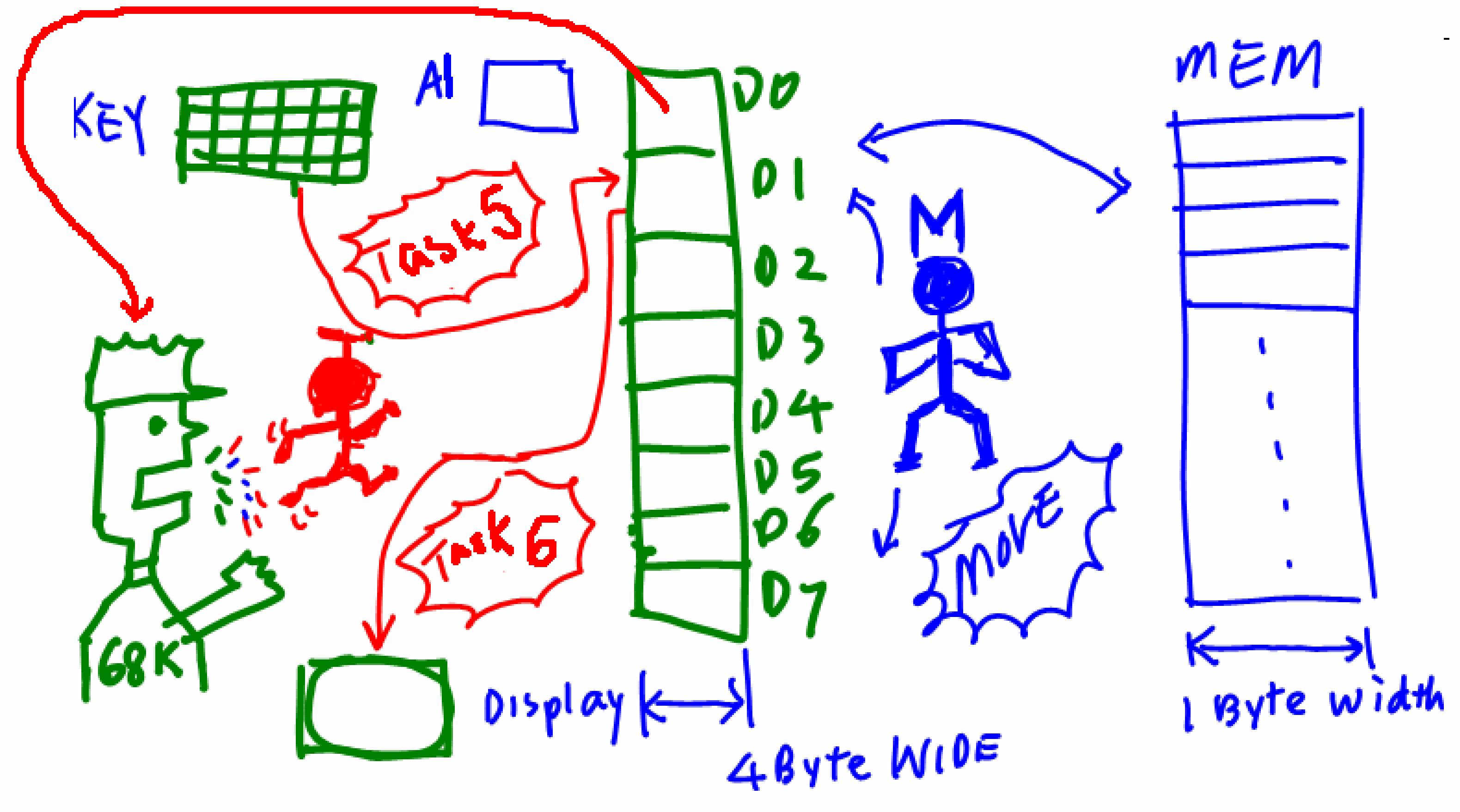
- RCHR
  - Read a character
  - Input: Key-in
  - Output: Key-in is stored in D1
- PCHR
  - Print a character
  - Input: a character stored in D1
  - Output: Display on Monitor
- EOFF
  - Echo-Off Declaration
  - Called once at top
  - Input: None
  - Output:None



```
; SUBROUTINES
RCHR    MOVE.B #5,  D0
        TRAP   #15
        RTS

PCHR    MOVE.B #6,  D0
        TRAP   #15
        RTS

EOFF    MOVE.B #0,D1
        MOVE.B #12,D0
        TRAP   #15
        RTS
```

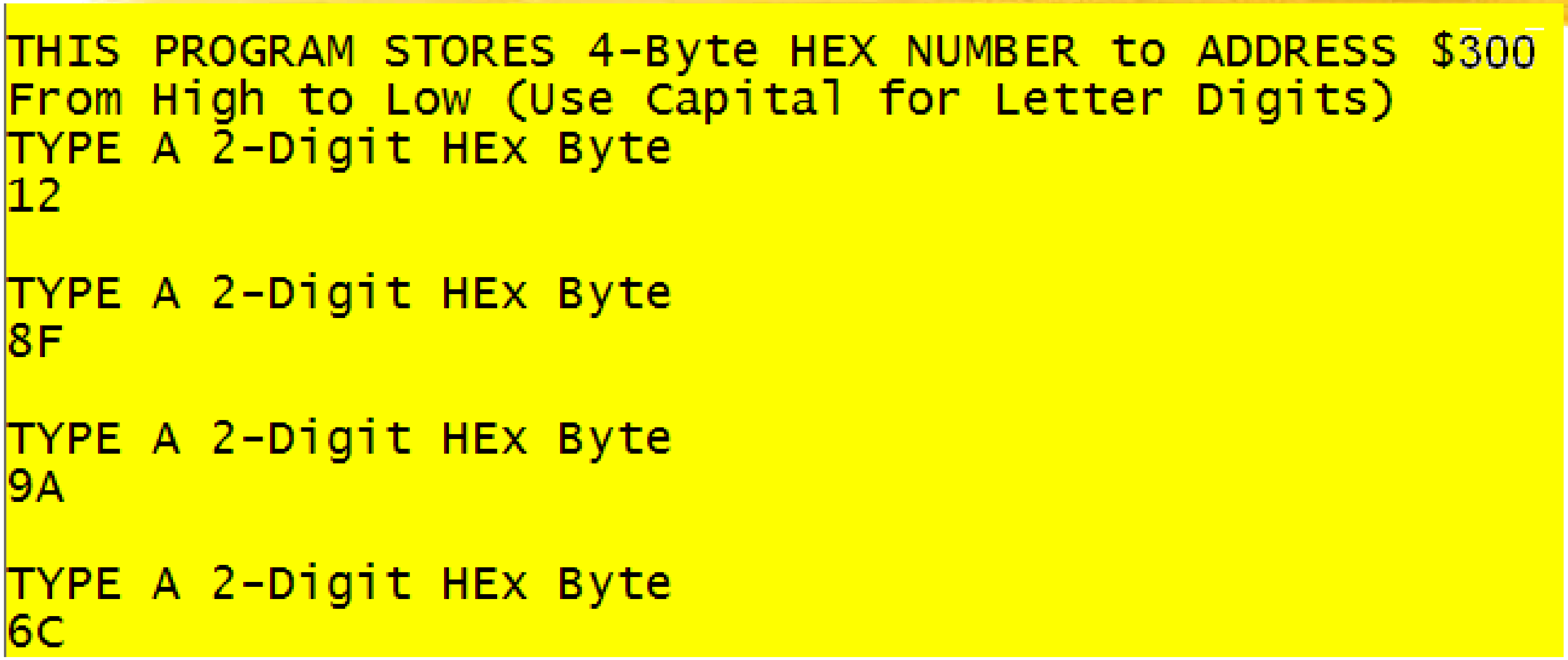
Moving between Data registers and Memory

- What if you need more than 7 long rooms?
  - **Well, in memory, there are many byte rooms. Millions!**



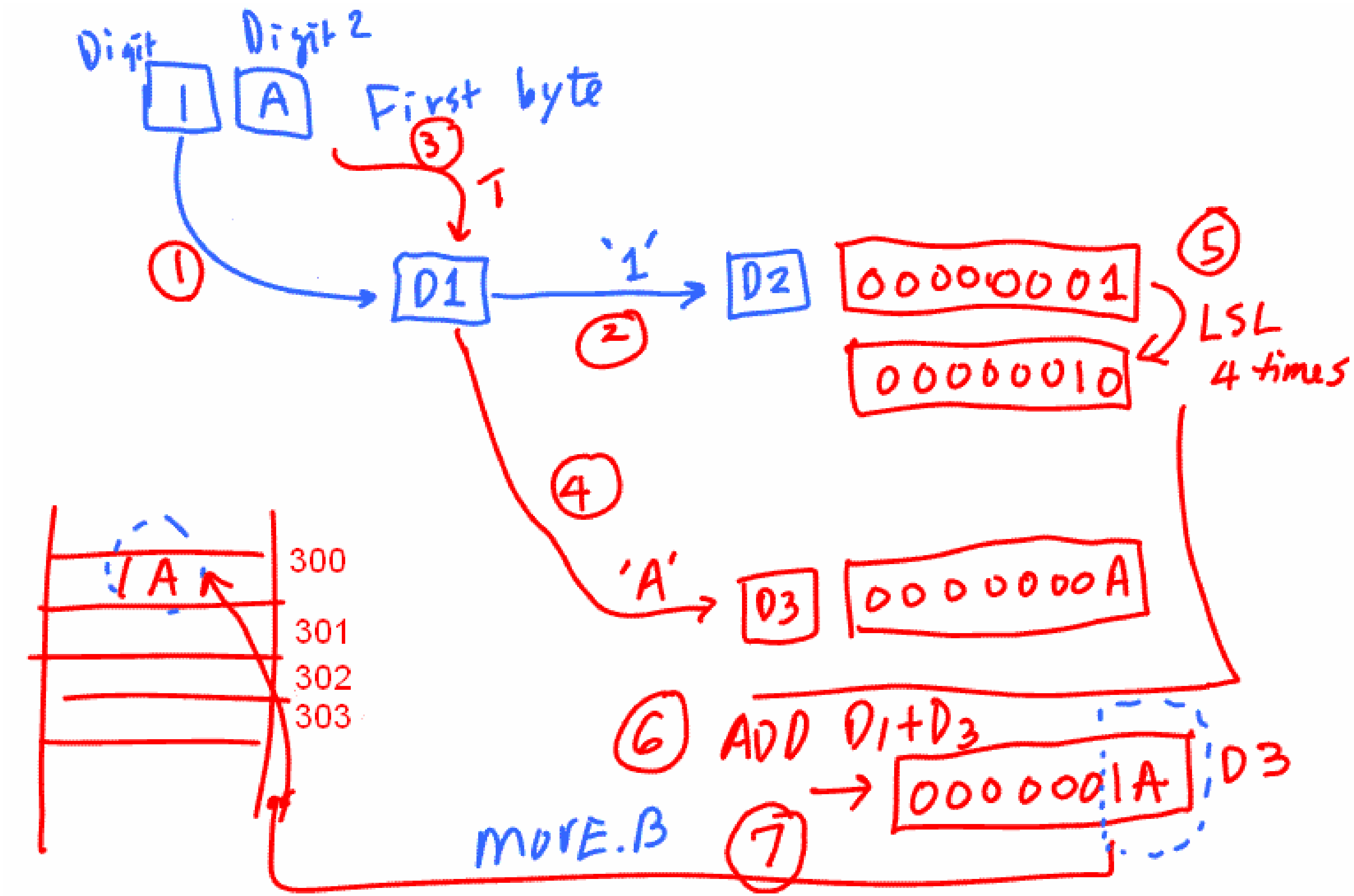
Exercise II (Moving to/from MEM)

- Storing Data Into Memory



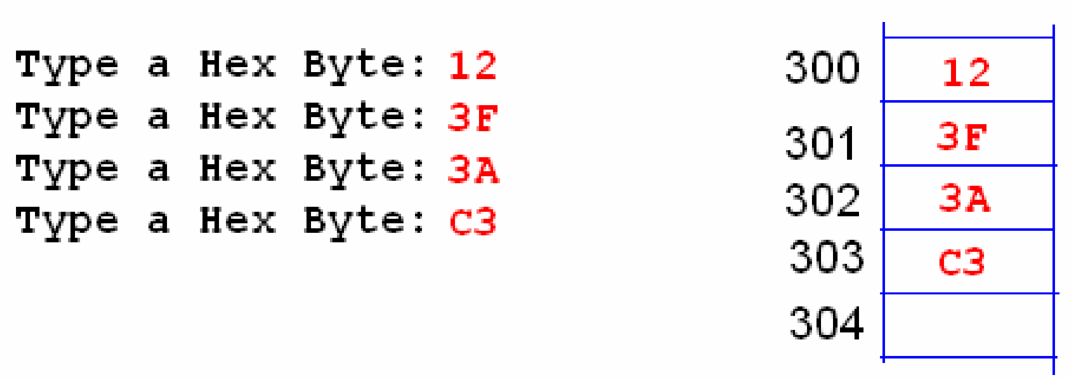
```
THIS PROGRAM STORES 4-Byte HEX NUMBER to ADDRESS $300
From High to Low (Use Capital for Letter Digits)
TYPE A 2-Digit HEx Byte
12

TYPE A 2-Digit HEx Byte
8F

TYPE A 2-Digit HEx Byte
9A

TYPE A 2-Digit HEx Byte
6C
```

Is this what will happen?



Exercise II-continued

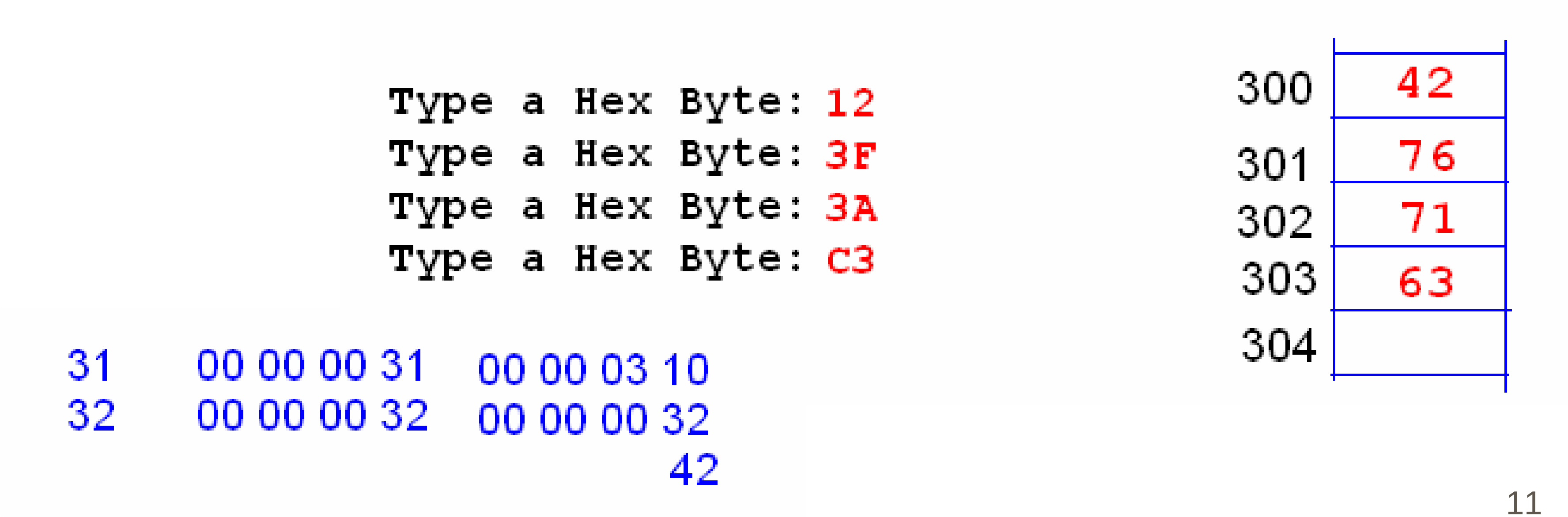
- This is what we want.



```
Type a Hex Byte: 12
Type a Hex Byte: 3F
Type a Hex Byte: 3A
Type a Hex Byte: C3
```

300	12
301	3F
302	3A
303	C3
304	

- This is what we will have. Why?

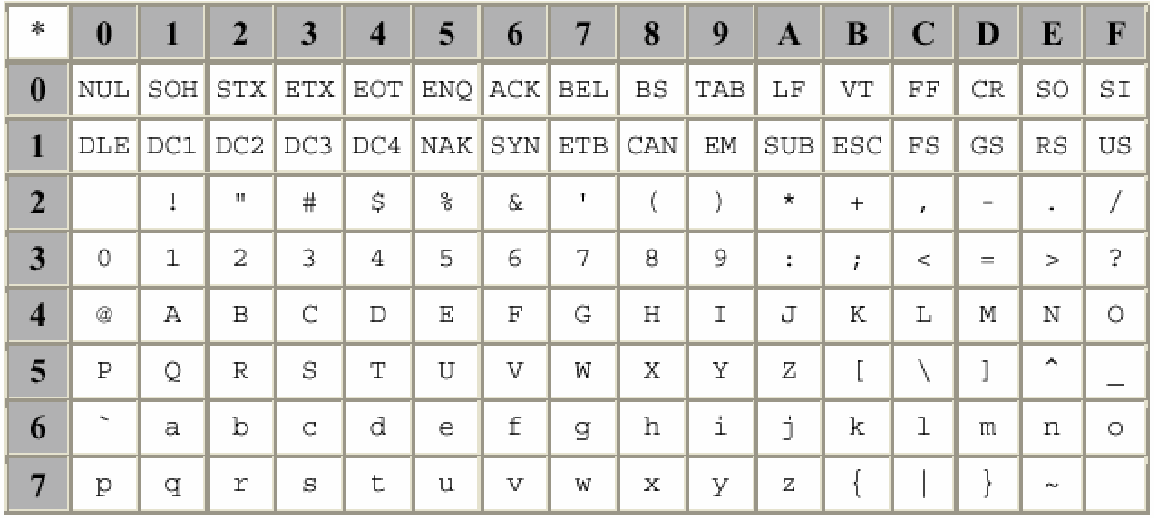


```
Type a Hex Byte: 12
Type a Hex Byte: 3F
Type a Hex Byte: 3A
Type a Hex Byte: C3
```

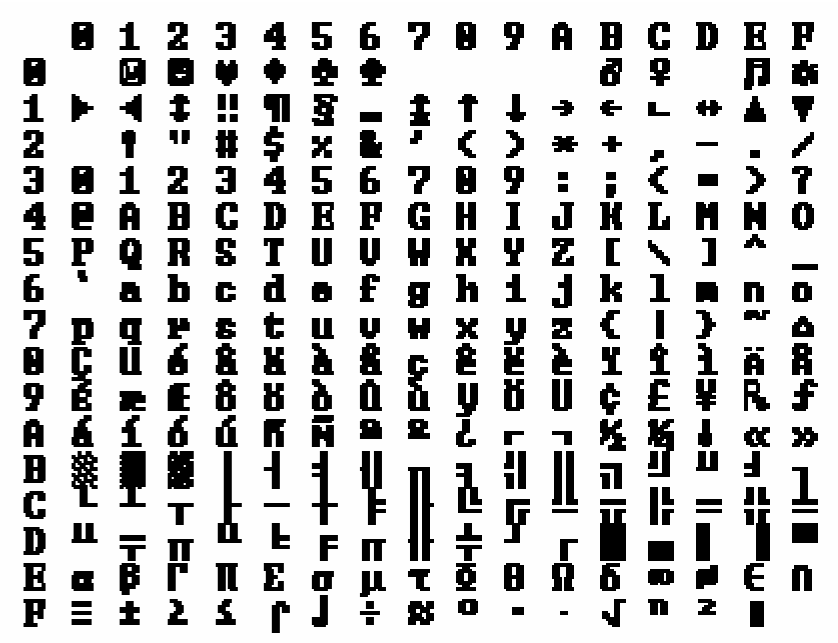
300	42
301	76
302	71
303	63
304	

```
31      00 00 00 31    00 00 03 10
32      00 00 00 32    00 00 00 32
                            42
```

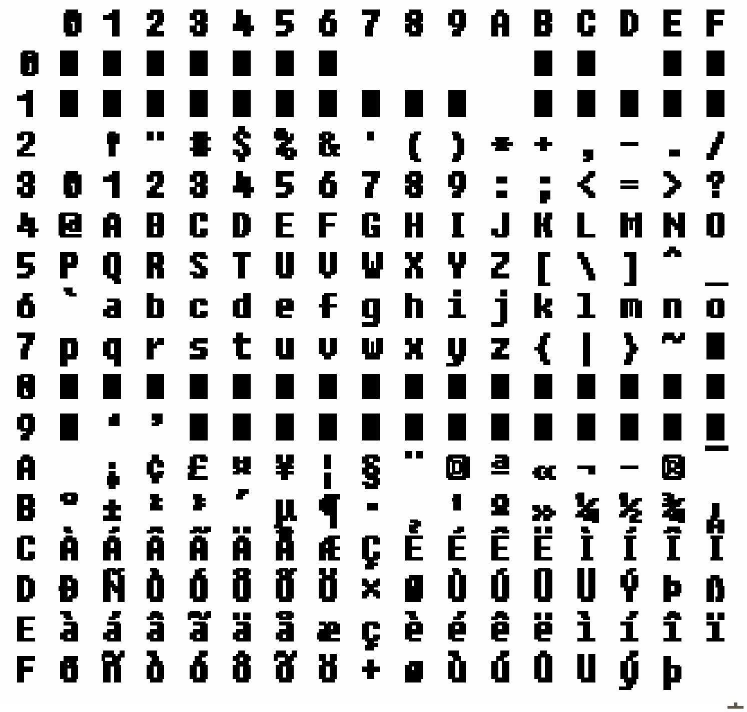
ASCII Code Chart



*	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	BS	TAB	LF	VT	FF	CR	SO	SI
1	DLE	DC1	DC2	DC3	DC4	NAK	SYN	ETB	CAN	EM	SUB	ESC	FS	GS	RS	US
2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	

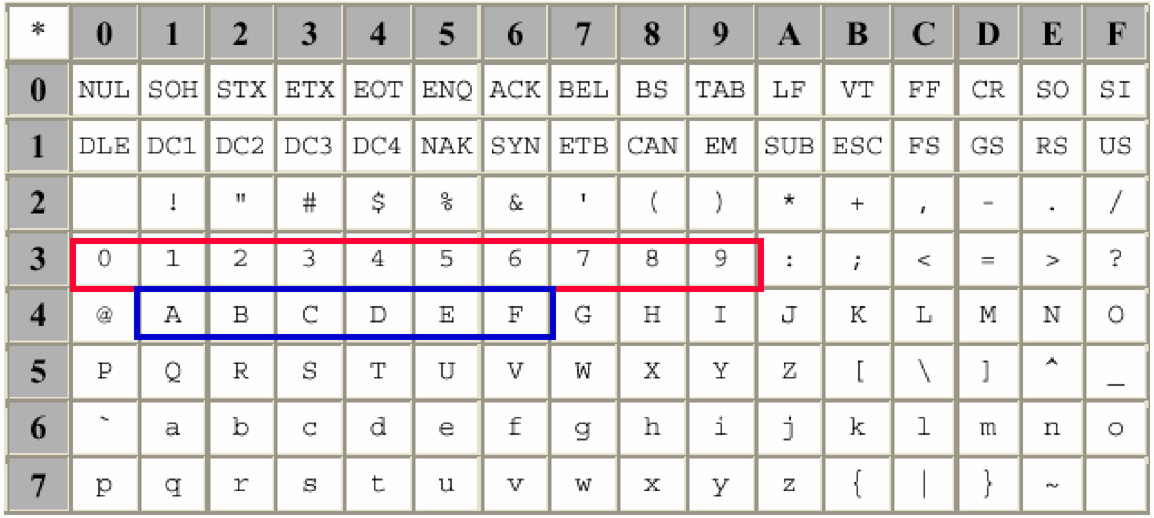


	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0		☺	☻	♥	♦	♣	♠					♂	♀		♫	☼
1	►	◄	↕	‼	¶	§	▬	↨	↑	↓	→	←	∟	↔	▲	▼
2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	⌂
8	Ç	ü	é	â	ä	à	å	ç	ê	ë	è	ï	î	ì	Ä	Å
9	É	æ	Æ	ô	ö	ò	û	ù	ÿ	Ö	Ü	¢	£	¥	₧	ƒ
A	á	í	ó	ú	ñ	Ñ	ª	º	¿	⌐	¬	½	¼	¡	«	»
B	░	▒	▓	│	┤	╡	╢	╖	╕	╣	║	╗	╝	╜	╛	┐
C	└	┴	┬	├	─	┼	╞	╟	╚	╔	╩	╦	╠	═	╬	╧
D	╨	╤	╥	╙	╘	╒	╓	╫	╪	┘	┌	█	▄	▌	▐	▀
E	α	ß	Γ	π	Σ	σ	µ	τ	Φ	Θ	Ω	δ	∞	φ	ε	∩
F	≡	±	≥	≤	⌠	⌡	÷	≈	°	∙	·	√	ⁿ	²	■	



	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	█	█	█	█	█	█	█					█	█		█	█
1	█	█	█	█	█	█	█	█	█	█		█	█	█	█	█
2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	█
8	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
9	█	'	'	█	█	█	█	█	█	█	█	█	█	█	█	█
A		¡	¢	£	¤	¥	¦	§	¨	©	ª	«	¬	-	®	¯
B	°	±	²	³	´	µ	¶	·		¹	º	»	¼	½	¾	¿
C	À	Á	Â	Ã	Ä	Å	Æ	Ç	È	É	Ê	Ë	Ì	Í	Î	Ï
D	Ð	Ñ	Ò	Ó	Ô	Õ	Ö	×	Ø	Ù	Ú	Û	Ü	Ý	Þ	ß
E	à	á	â	ã	ä	å	æ	ç	è	é	ê	ë	ì	í	î	ï
F	ð	ñ	ò	ó	ô	õ	ö	÷	ø	ù	ú	û	ü	ý	þ	

ASCII-to-HEX Conversion



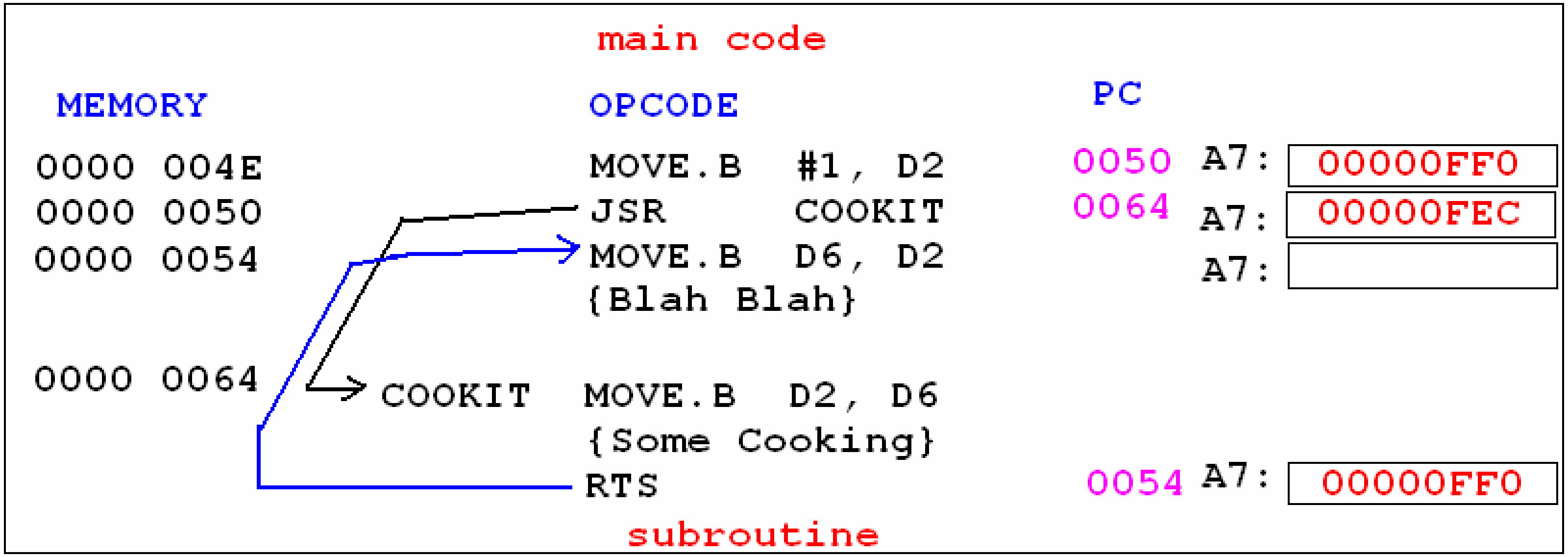
*	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	BS	TAB	LF	VT	FF	CR	SO	SI
1	DLE	DC1	DC2	DC3	DC4	NAK	SYN	ETB	CAN	EM	SUB	ESC	FS	GS	RS	US
2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	

- Task #5
  - A Character (in ASCII code (of a Byte size)) in D1
- Conversion of the Byte in ASCII into a Hex Number
- Numeric or Alpha?
  - $30 - $39 → D1=D1-$30
  - $41 - $46 → D1=D1-$37
  - All others → “error message”

Subroutine and Stack

- Subroutine
  - Name= label
  - Ends with **RTS**
- Calling
  - Call by **JSR** or **BSR**
  - Changing PC to the Label (or starting address) of a Subroutine
  - Program should know the return address after visiting the subroutine
- Stack
  - The return address (the address just after the calling instruction) is stored in the Stack
  - Stack is also in the **Memory** (size of Long Word) **starting @00000FF0 and decreasing.** **So, program code should not mess with stack memory area.**
  - The Stack address is stored in Address register, A7 (“stack pointer”)
  - LIFO (Last In First Out) Structure
  - PUSH and POP
- PC gets “Address for next instruction” at the memory location pointed by A7

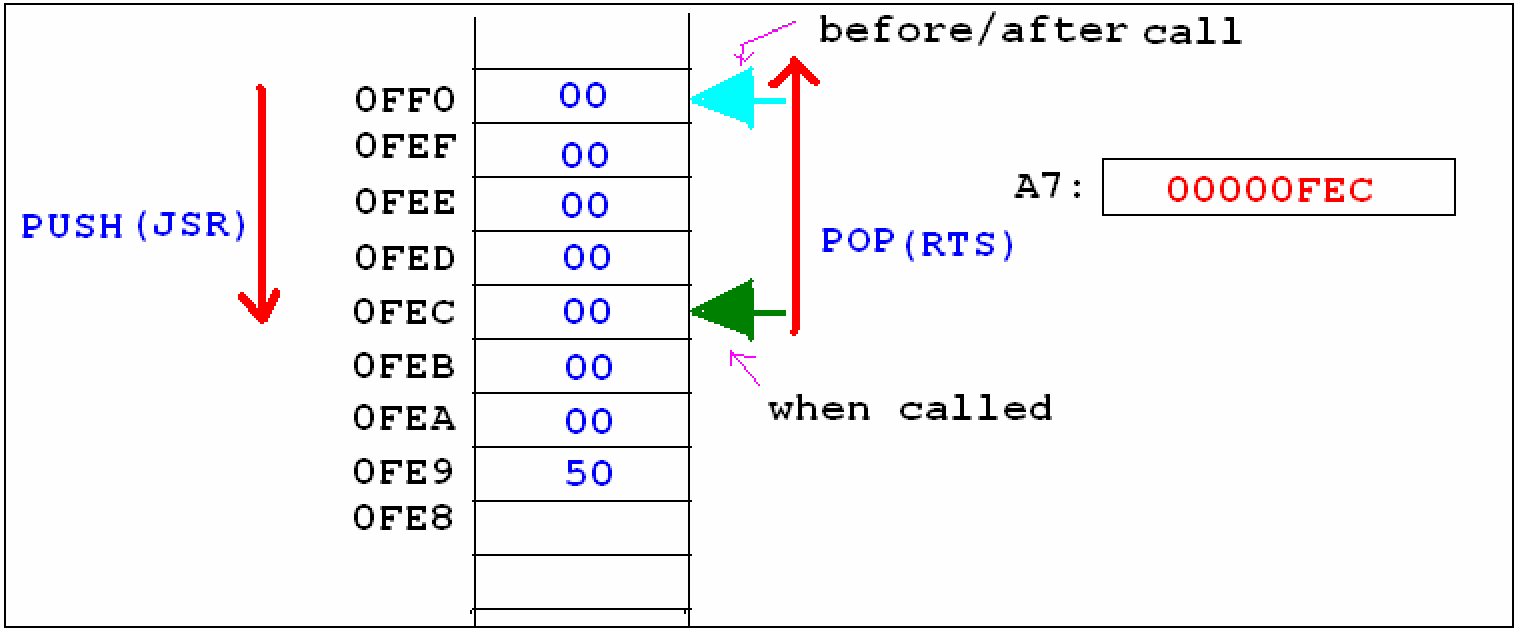
Subroutine and Stack



main code

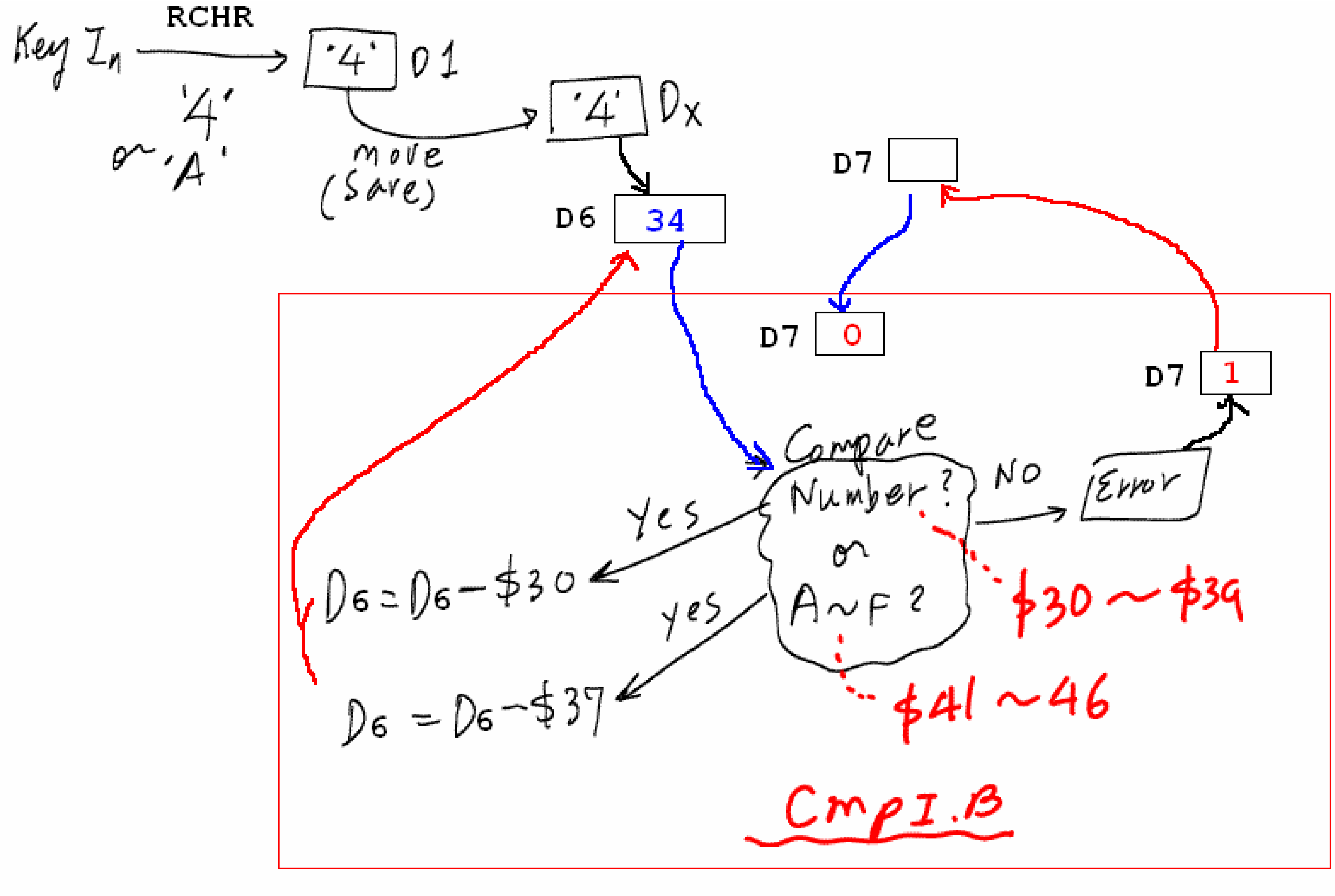
```
MEMORY                         OPCODE                   PC
0000 004E                      MOVE.B   #1, D2          0050  A7: 00000FF0
0000 0050                      JSR      COOKIT          0064  A7: 00000FEC
0000 0054                      MOVE.B   D6, D2                A7:
                               {Blah Blah}

0000 0064        COOKIT        MOVE.B   D2, D6
                               {Some Cooking}
                               RTS                      0054  A7: 00000FF0
```

subroutine

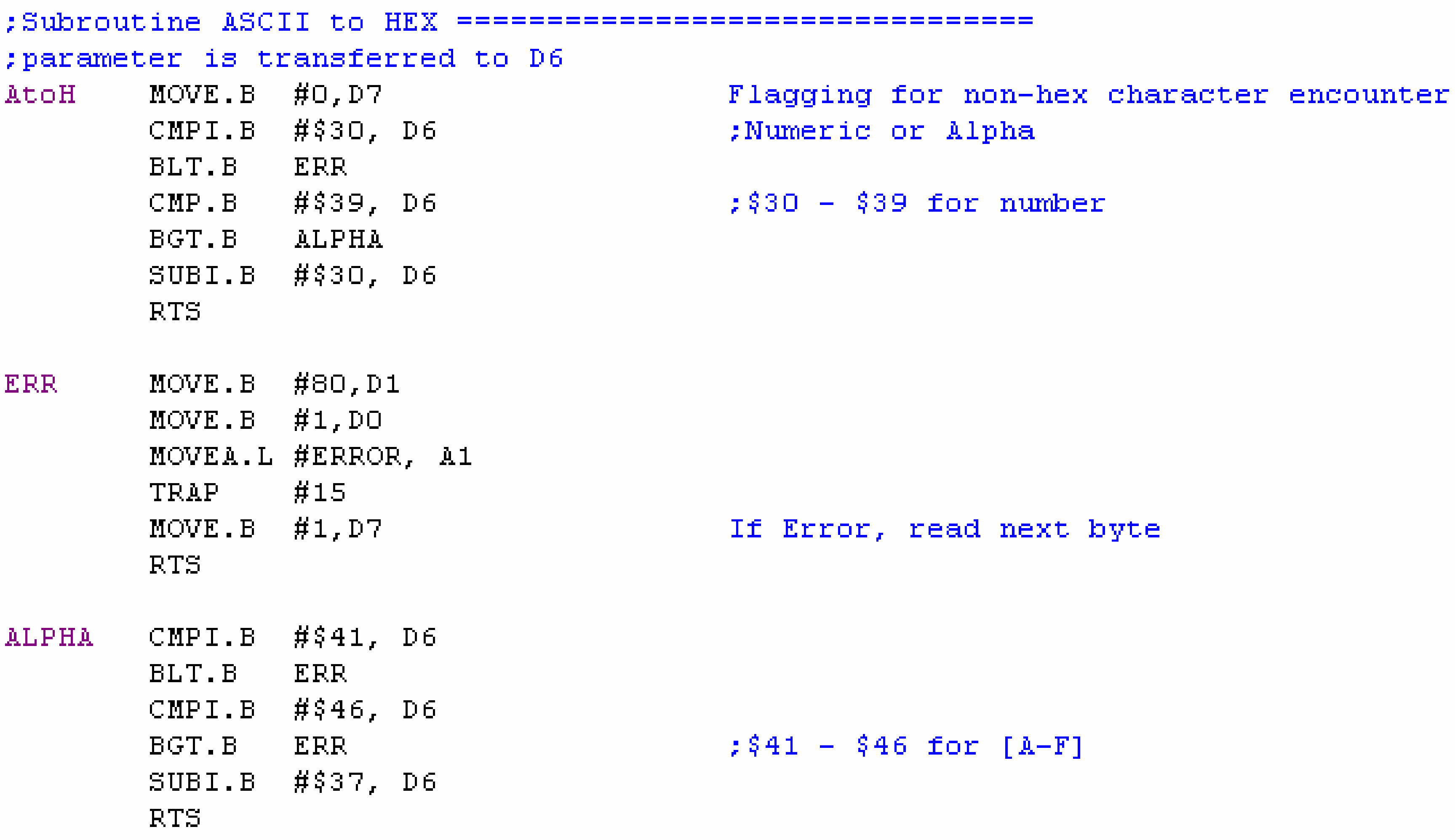


0FF0	00
0FEF	00
0FEE	00
0FED	00
0FEC	00
0FEB	00
0FEA	00
0FE9	50
0FE8	

ATOH: ASCII to HEX Conversion Subroutine

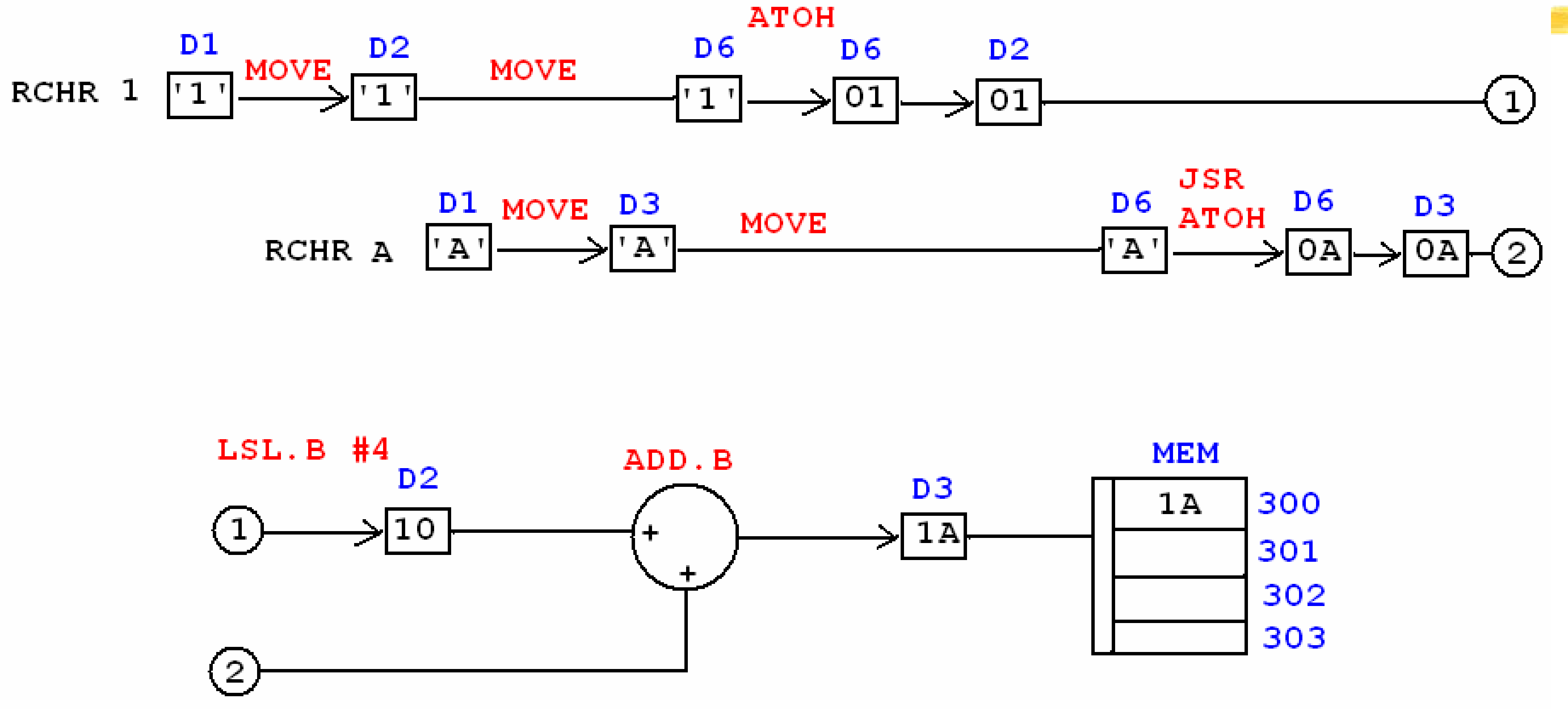


Subroutine ATOH (ASCII-to-Hex)



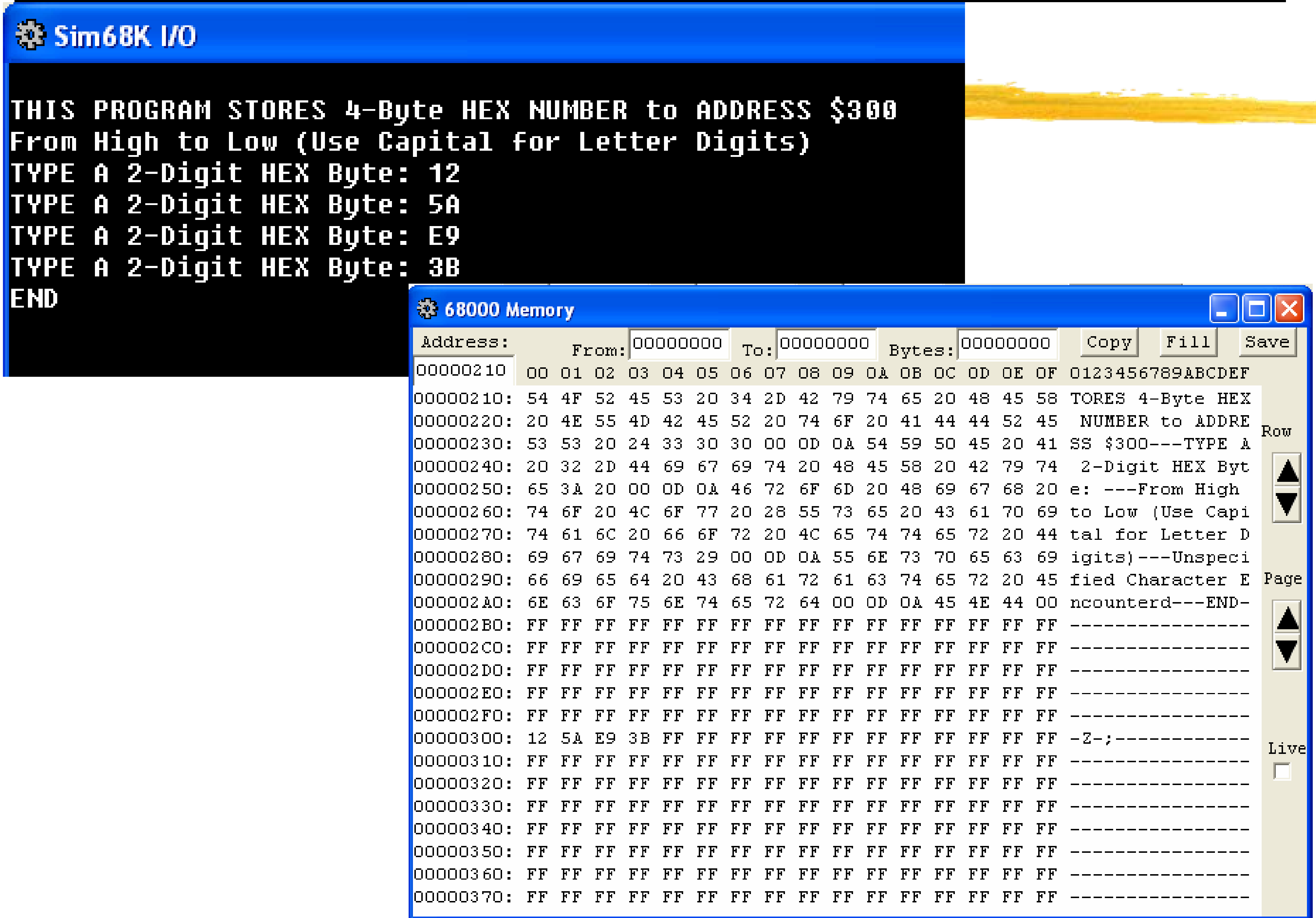
```
;Subroutine ASCII to HEX ================================
;parameter is transferred to D6
AtoH    MOVE.B  #0,D7                   Flagging for non-hex character encounter
        CMPI.B  #$30, D6                ;Numeric or Alpha
        BLT.B   ERR
        CMP.B   #$39, D6                ;$30 - $39 for number
        BGT.B   ALPHA
        SUBI.B  #$30, D6
        RTS

ERR     MOVE.B  #80,D1
        MOVE.B  #1,D0
        MOVEA.L #ERROR, A1
        TRAP    #15
        MOVE.B  #1,D7                   If Error, read next byte
        RTS

ALPHA   CMPI.B  #$41, D6
        BLT.B   ERR
        CMPI.B  #$46, D6
        BGT.B   ERR                     ;$41 - $46 for [A-F]
        SUBI.B  #$37, D6
        RTS
```

Code structure for HEX-to-MEM



⌘Name the code Hex2Mem.X68.

Running Result



Sim68K I/O

```
THIS PROGRAM STORES 4-Byte HEX NUMBER to ADDRESS $300
From High to Low (Use Capital for Letter Digits)
TYPE A 2-Digit HEX Byte: 12
TYPE A 2-Digit HEX Byte: 5A
TYPE A 2-Digit HEX Byte: E9
TYPE A 2-Digit HEX Byte: 3B
END
```

68000 Memory

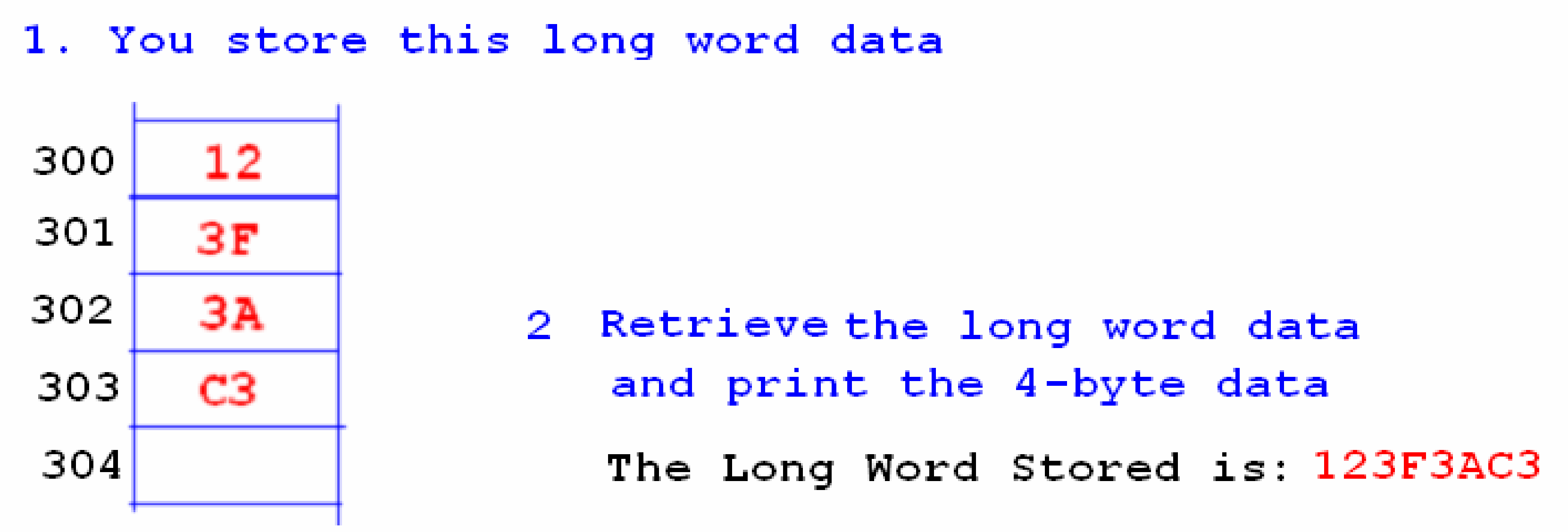
Address: 00000210 From: 00000000 To: 00000000 Bytes: 00000000 Copy Fill Save

Row Page Live □

```
           00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F 0123456789ABCDEF
00000210:  54 4F 52 45 53 20 34 2D 42 79 74 65 20 48 45 58 TORES 4-Byte HEX
00000220:  20 4E 55 4D 42 45 52 20 74 6F 20 41 44 44 52 45  NUMBER to ADDRE
00000230:  53 53 20 24 33 30 30 00 0D 0A 54 59 50 45 20 41 SS $300---TYPE A
00000240:  20 32 2D 44 69 67 69 74 20 48 45 58 20 42 79 74  2-Digit HEX Byt
00000250:  65 3A 20 00 0D 0A 46 72 6F 6D 20 48 69 67 68 20 e: ---From High 
00000260:  74 6F 20 4C 6F 77 20 28 55 73 65 20 43 61 70 69 to Low (Use Capi
00000270:  74 61 6C 20 66 6F 72 20 4C 65 74 74 65 72 20 44 tal for Letter D
00000280:  69 67 69 74 73 29 00 0D 0A 55 6E 73 70 65 63 69 igits)---Unspeci
00000290:  66 69 65 64 20 43 68 61 72 61 63 74 65 72 20 45 fied Character E
000002A0:  6E 63 6F 75 6E 74 65 72 64 00 0D 0A 45 4E 44 00 ncounterd---END-
000002B0:  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
000002C0:  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
000002D0:  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
000002E0:  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
000002F0:  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000300:  12 5A E9 3B FF FF FF FF FF FF FF FF FF FF FF FF -Z-;------------
00000310:  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000320:  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000330:  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000340:  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000350:  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000360:  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000370:  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
```

Exercise III

- Problem: Retrieve the long word (I.e., 4 bytes) stored at the location starting at $300, and print each byte, from highest to lowest, on the computer screen.
- This is what we want.



1. You store this long word data

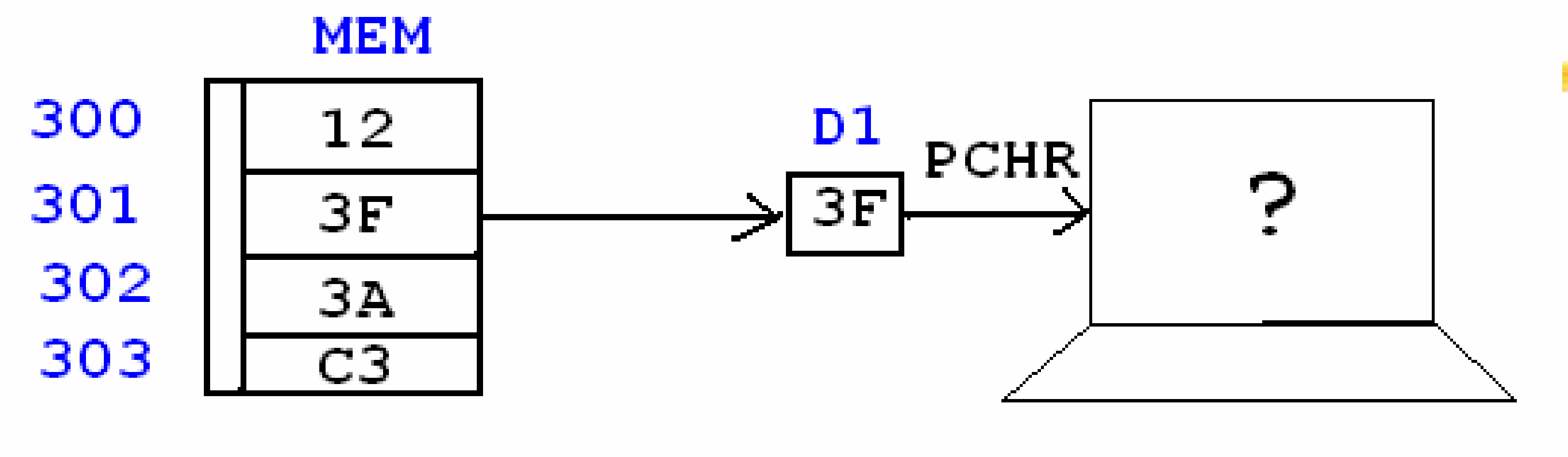
300	12
301	3F
302	3A
303	C3
304	

2 Retrieve the long word data and print the 4-byte data

The Long Word Stored is: 123F3AC3

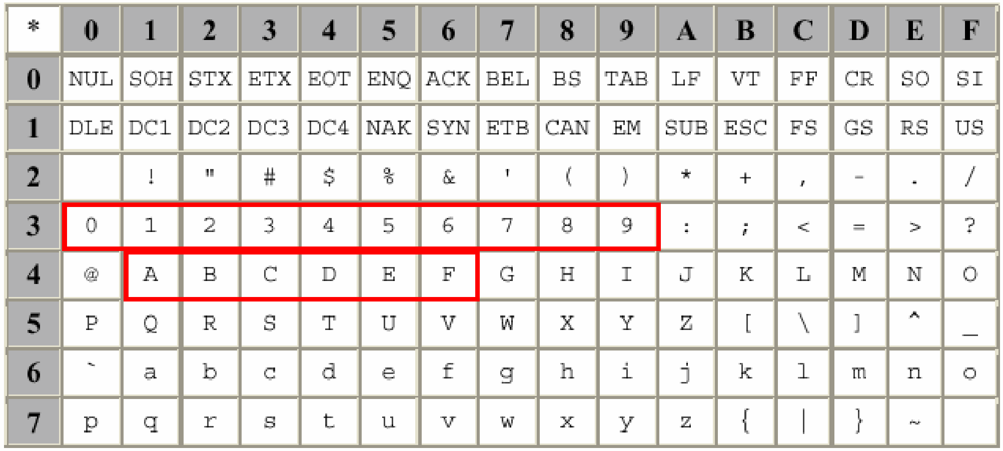
- Need: Conversion of HEX to ASCII (HtoA)

Naïve Approach (without HtoA)

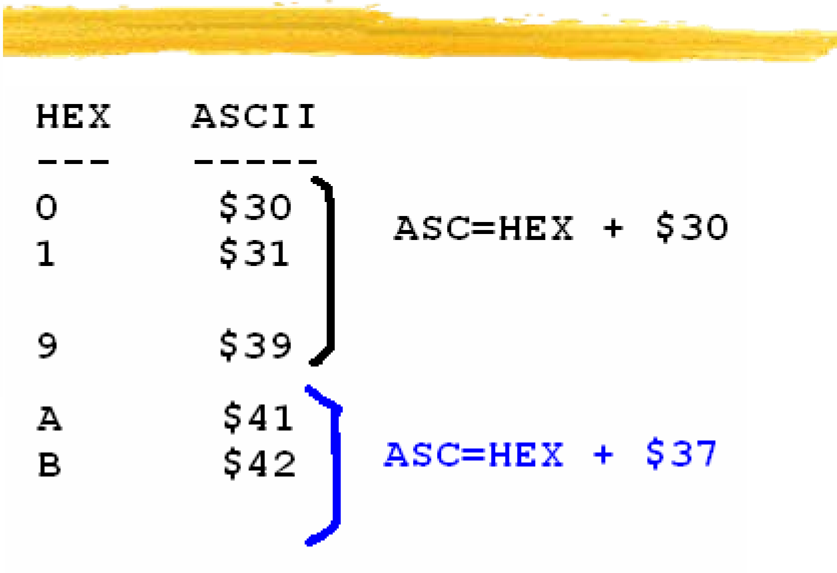


- ASCII Treatment
  - To Monitor
  - From Keyboard
  - Through D1
  - PCHR & RCHR

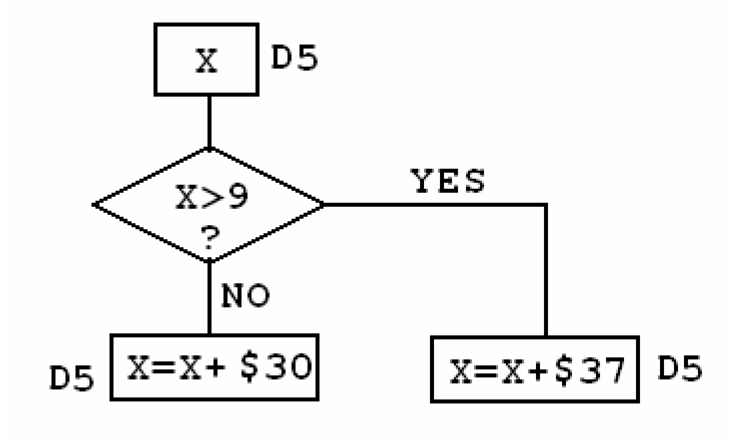
Hex to ASCII Conversion (HtoA)

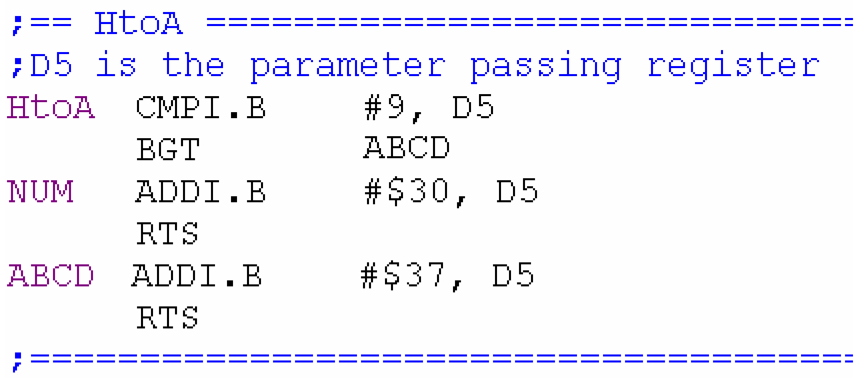


*	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	BS	TAB	LF	VT	FF	CR	SO	SI
1	DLE	DC1	DC2	DC3	DC4	NAK	SYN	ETB	CAN	EM	SUB	ESC	FS	GS	RS	US
2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	



```
HEX     ASCII
---     -----
0        $30
1        $31      ASC=HEX + $30

9        $39

A        $41
B        $42      ASC=HEX + $37
```

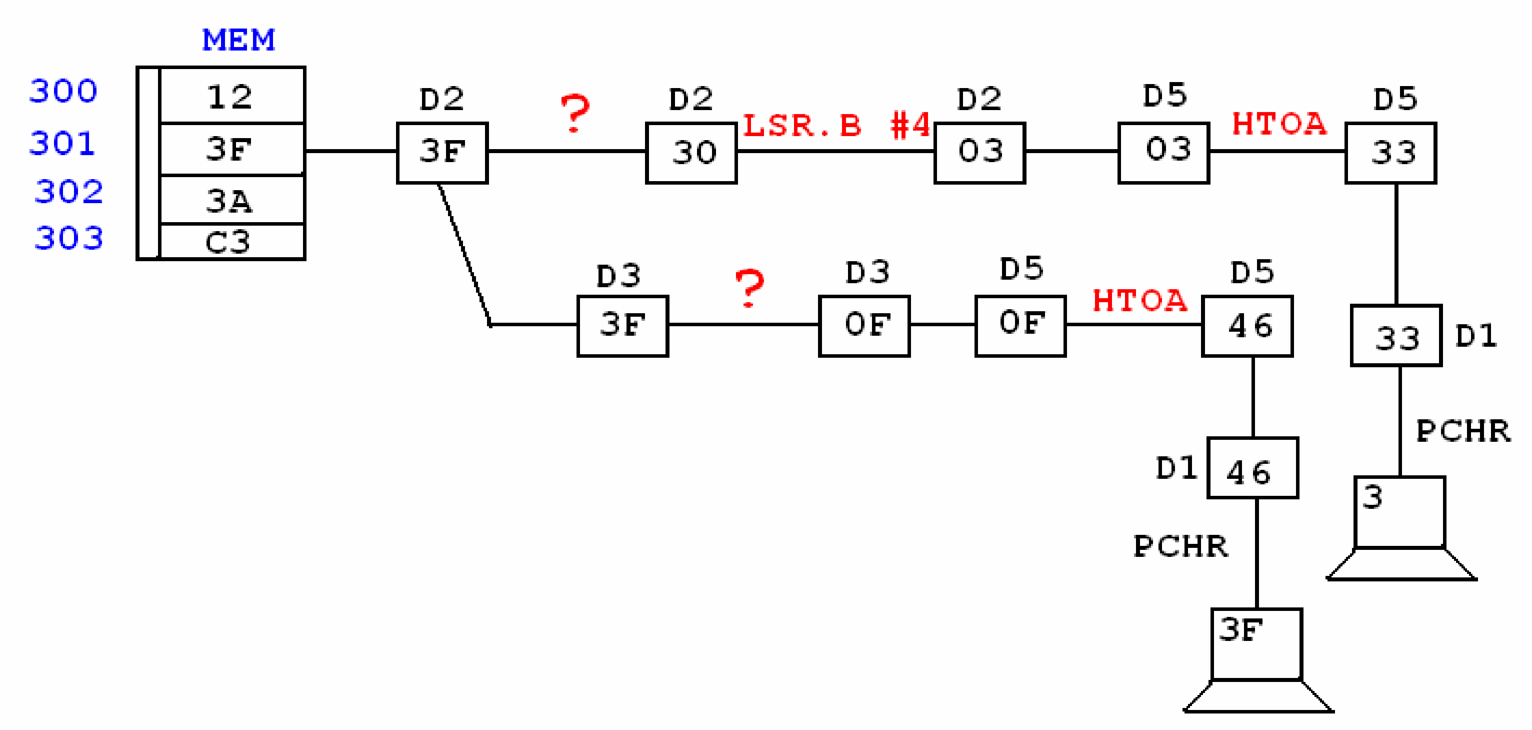




```
;== HtoA ===================================
;D5 is the parameter passing register
HtoA   CMPI.B     #9, D5
       BGT        ABCD
NUM    ADDI.B     #$30, D5
       RTS
ABCD   ADDI.B     #$37, D5
       RTS
;==========================================
```

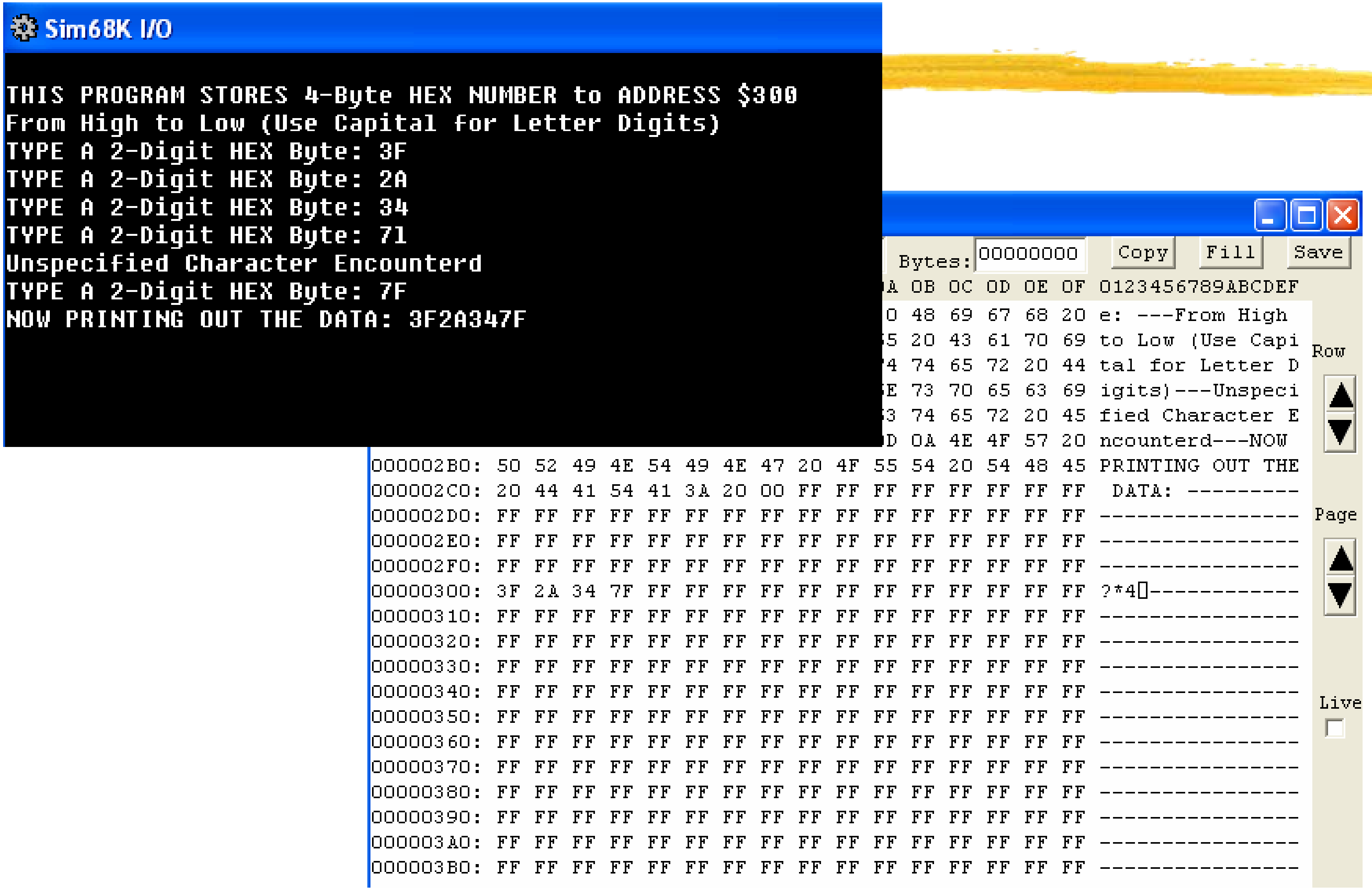
Code Structure

- Overall Code
  - Start with A2H code
  - Use A2H for writing 4 hex bytes into MEM
  - Add new lines for retrieving and printing them



- Save code to HEX2ASC.X68

Code Run Example

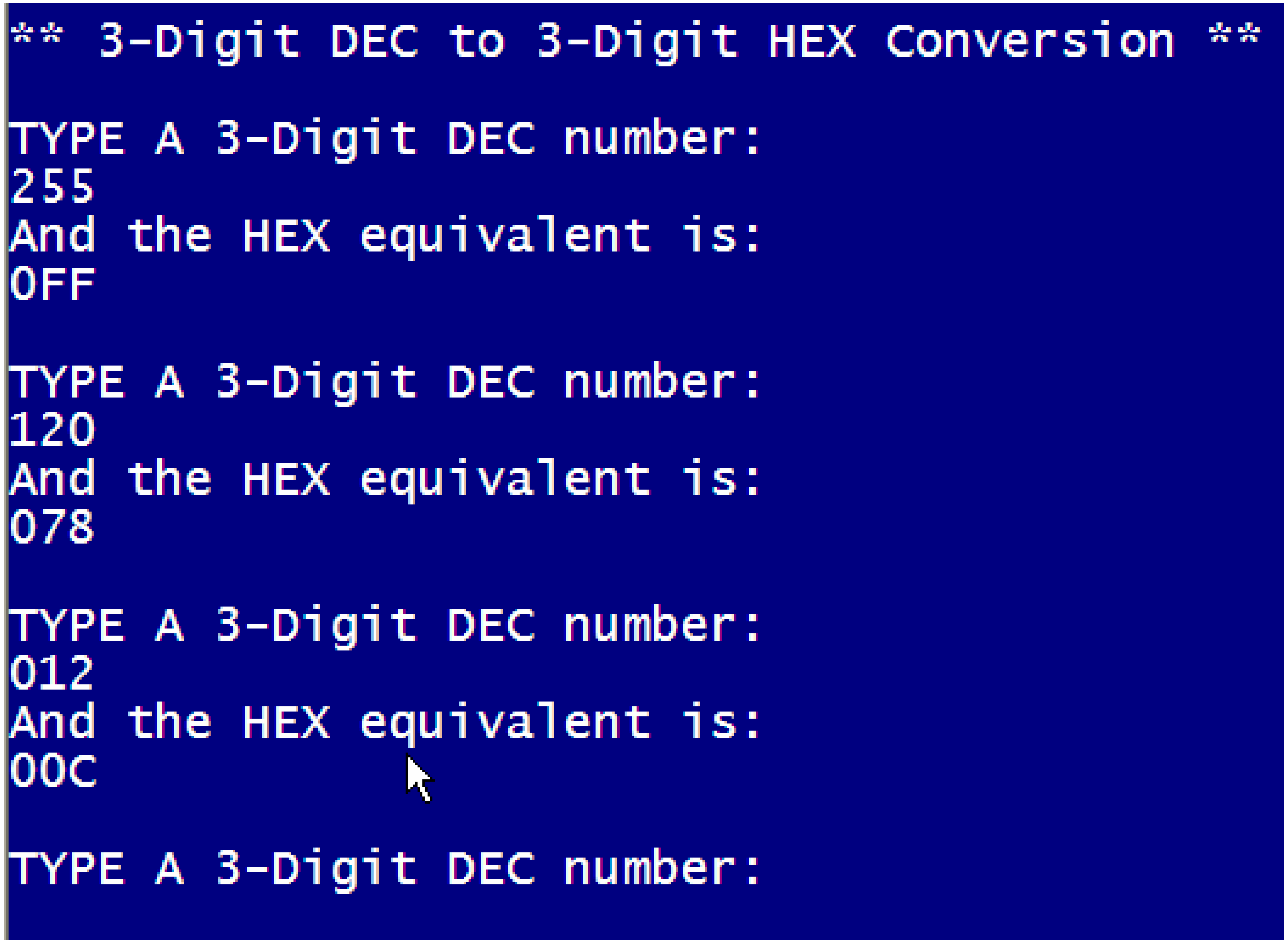


```
THIS PROGRAM STORES 4-Byte HEX NUMBER to ADDRESS $300
From High to Low (Use Capital for Letter Digits)
TYPE A 2-Digit HEX Byte: 3F
TYPE A 2-Digit HEX Byte: 2A
TYPE A 2-Digit HEX Byte: 34
TYPE A 2-Digit HEX Byte: 71
Unspecified Character Encounterd
TYPE A 2-Digit HEX Byte: 7F
NOW PRINTING OUT THE DATA: 3F2A347F
```

```
Bytes: 00000000
A 0B 0C 0D 0E 0F 0123456789ABCDEF
0 48 69 67 68 20 e: ---From High
5 20 43 61 70 69 to Low (Use Capi
4 74 65 72 20 44 tal for Letter D
E 73 70 65 63 69 igits)---Unspeci
3 74 65 72 20 45 fied Character E
D 0A 4E 4F 57 20 ncounterd---NOW
000002B0: 50 52 49 4E 54 49 4E 47 20 4F 55 54 20 54 48 45 PRINTING OUT THE
000002C0: 20 44 41 54 41 3A 20 00 FF FF FF FF FF FF FF FF  DATA: ---------
000002D0: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
000002E0: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
000002F0: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000300: 3F 2A 34 7F FF FF FF FF FF FF FF FF FF FF FF FF ?*4▯------------
00000310: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000320: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000330: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000340: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000350: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000360: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000370: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000380: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
00000390: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
000003A0: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
000003B0: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ----------------
```

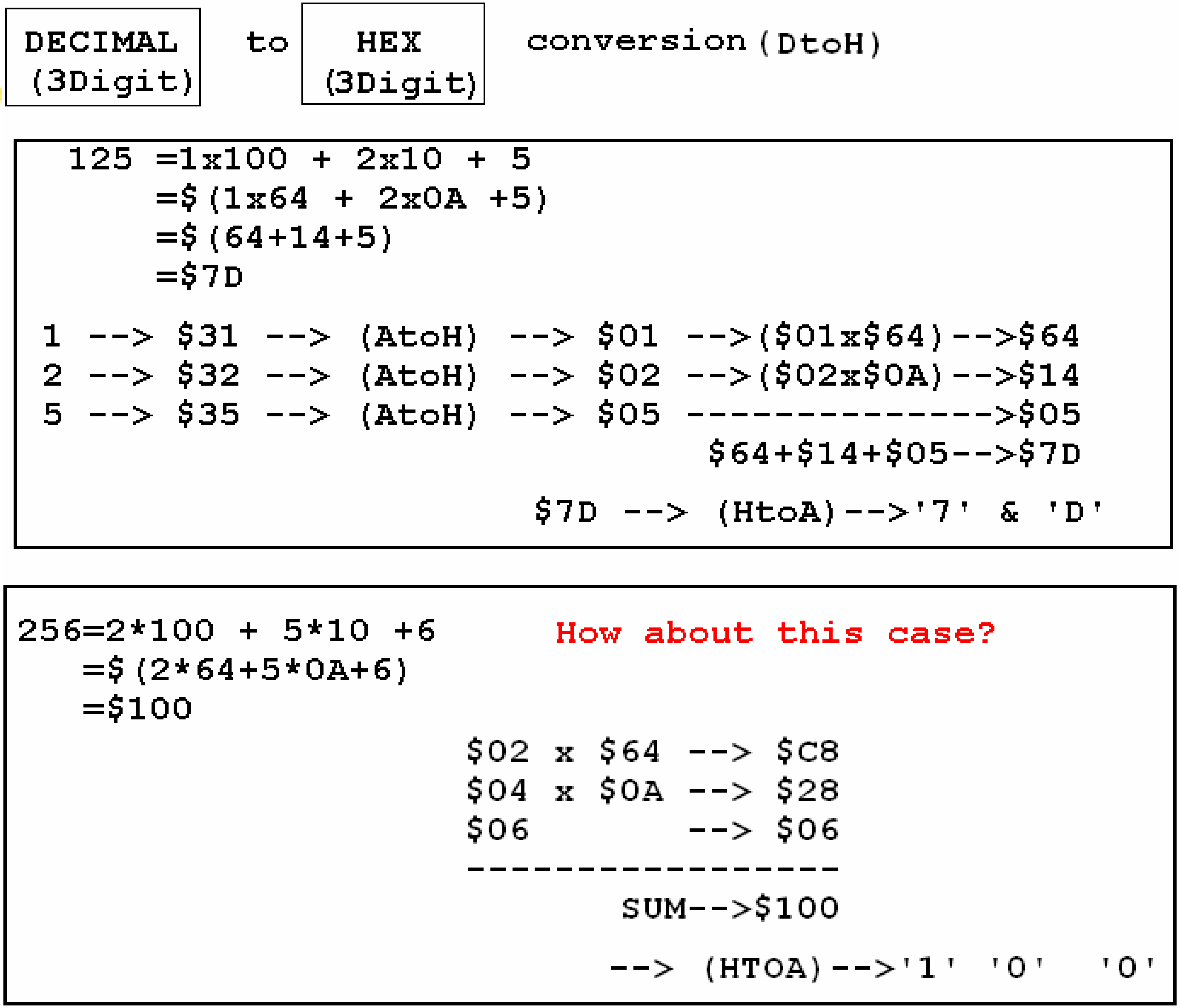
Exercise IV

- DEC to HEX Conversion



```
** 3-Digit DEC to 3-Digit HEX Conversion **

TYPE A 3-Digit DEC number:
255
And the HEX equivalent is:
0FF

TYPE A 3-Digit DEC number:
120
And the HEX equivalent is:
078

TYPE A 3-Digit DEC number:
012
And the HEX equivalent is:
00C

TYPE A 3-Digit DEC number:
```

DEC to HEX Conversion – Background



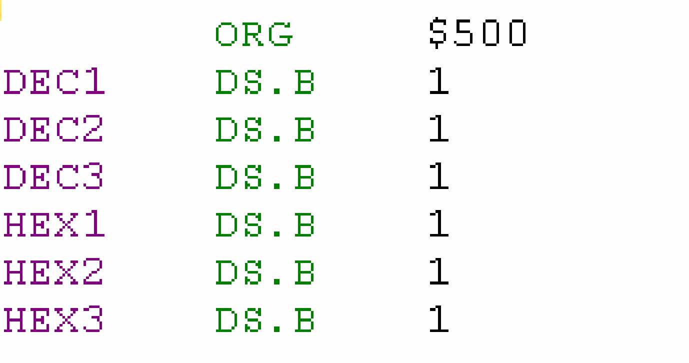
```
DECIMAL      to    HEX        conversion(DtoH)
(3Digit)          (3Digit)
```

```
  125 =1x100 + 2x10 + 5
      =$(1x64 + 2x0A +5)
      =$(64+14+5)
      =$7D

1 --> $31 --> (AtoH) --> $01 -->($01x$64)-->$64
2 --> $32 --> (AtoH) --> $02 -->($02x$0A)-->$14
5 --> $35 --> (AtoH) --> $05 --------------->$05
                             $64+$14+$05-->$7D

                   $7D --> (HtoA)-->'7' & 'D'
```

```
256=2*100 + 5*10 +6        How about this case?
   =$(2*64+5*0A+6)
   =$100
                          $02 x $64 --> $C8
                          $04 x $0A --> $28
                          $06       --> $06
                          -----------------
                                SUM-->$100

                               --> (HTOA)-->'1' '0'  '0'
```

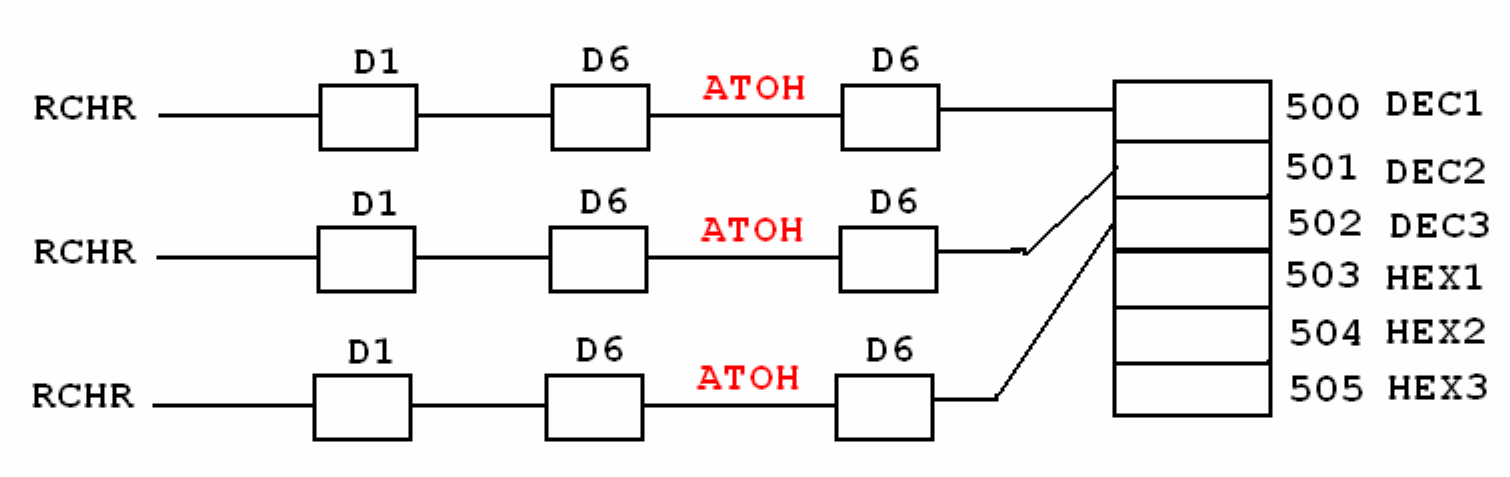
Pre-Processing

- Declaration of Memory Location by Label

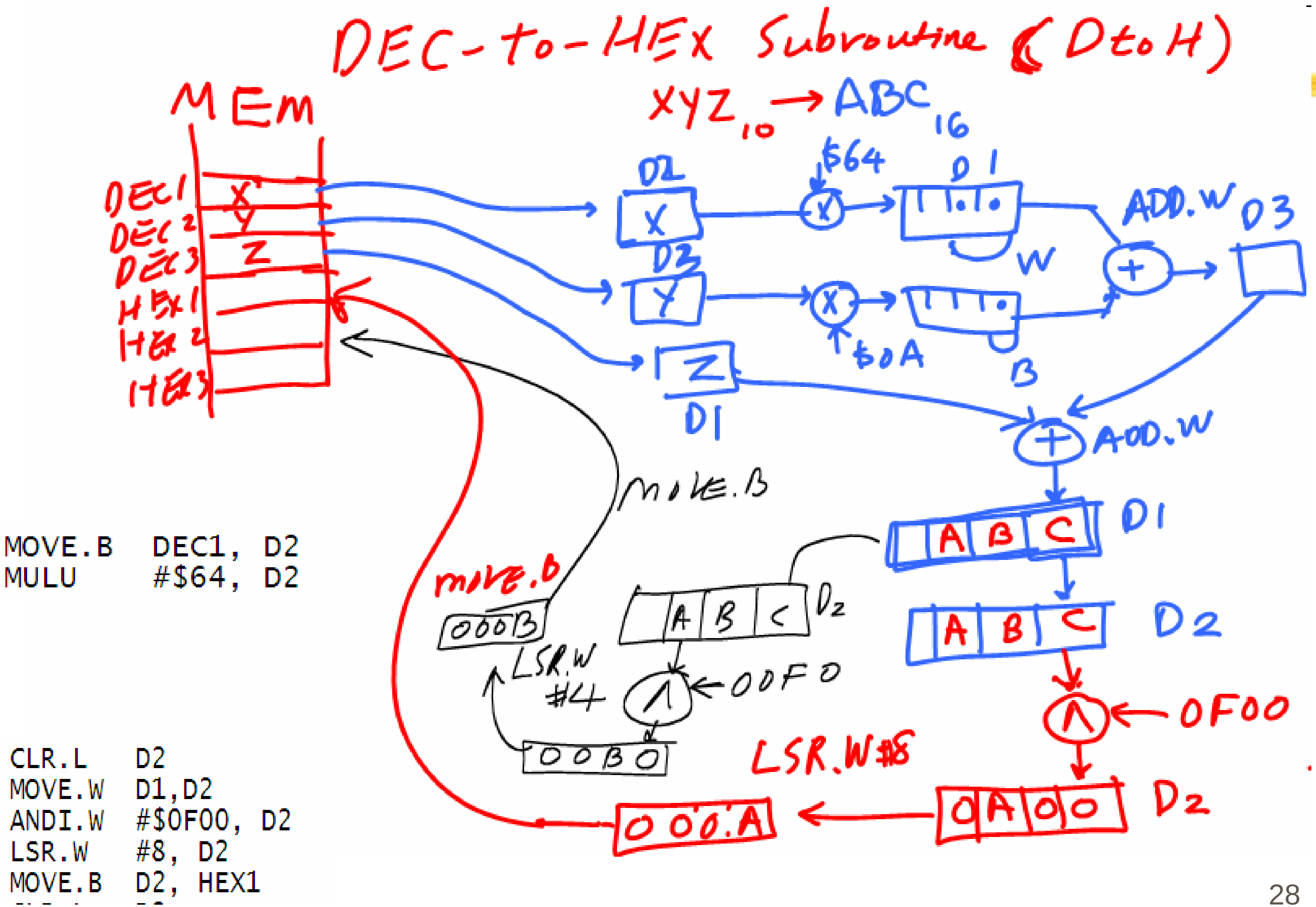


```
          ORG     $500
DEC1      DS.B    1
DEC2      DS.B    1
DEC3      DS.B    1
HEX1      DS.B    1
HEX2      DS.B    1
HEX3      DS.B    1
```

- Read 3 digit Decimal Number
- Store each digit from $500 as Number (by calling AtoH subroutine)



D2H Subroutine Structure - Sketch

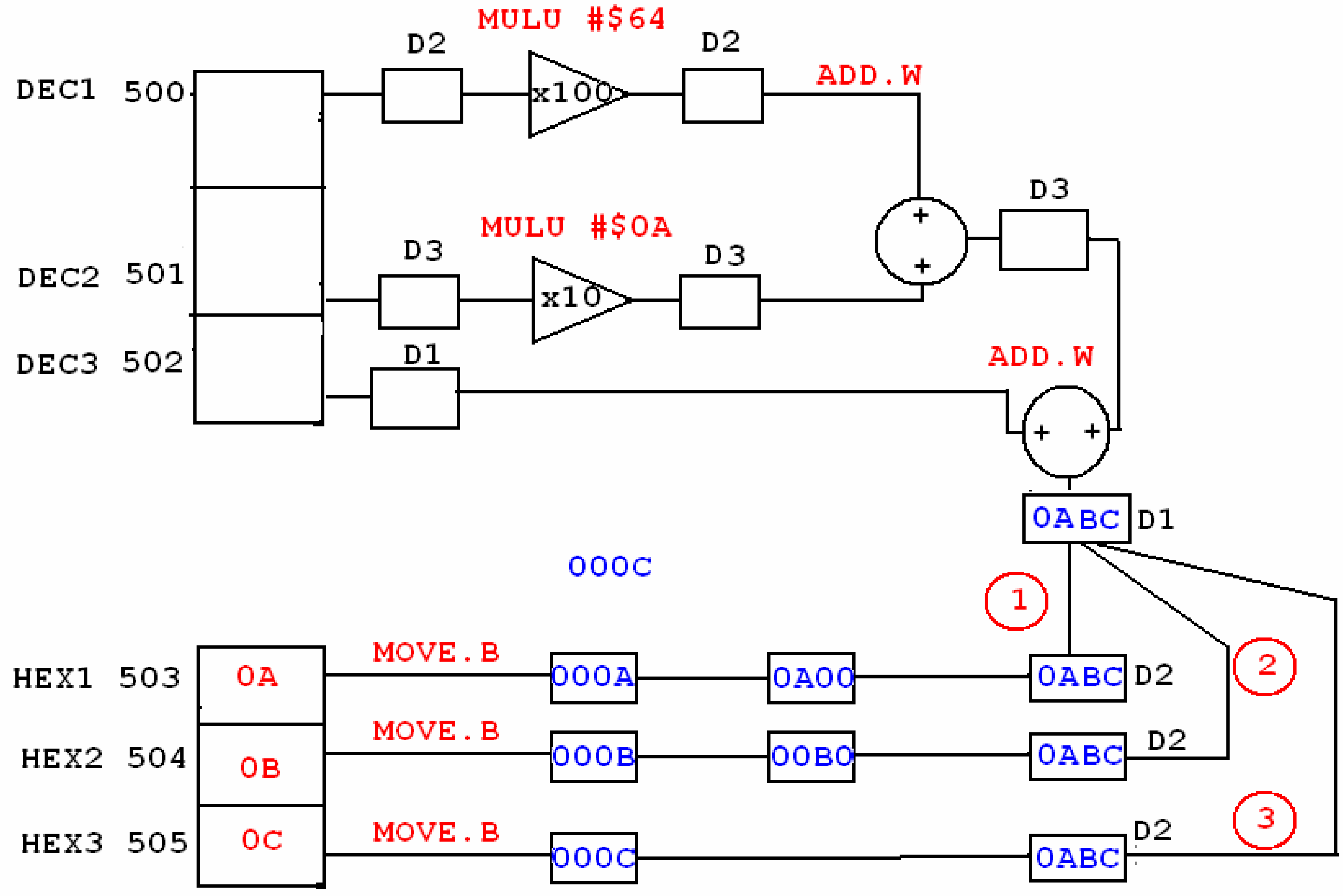


```
MOVE.B   DEC1, D2
MULU     #$64, D2
```

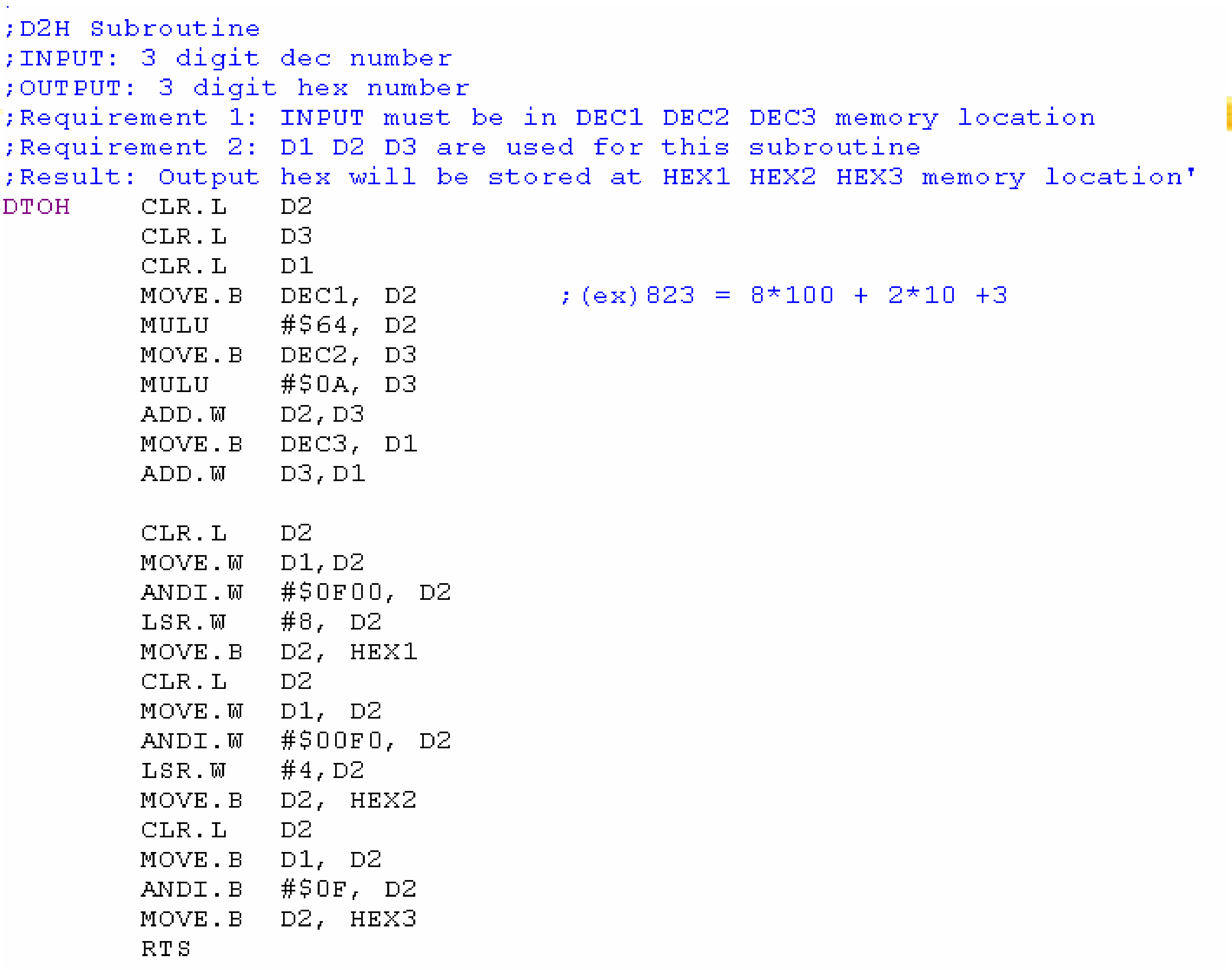
```
CLR.L    D2
MOVE.W   D1,D2
ANDI.W   #$0F00, D2
LSR.W    #8, D2
MOVE.B   D2, HEX1
```

DtoH - Subroutine

- Read 3 numbers starting from $500 and store into Data Registers
- Convert them into 3 hex digits
- Store hex bytes starting from $503



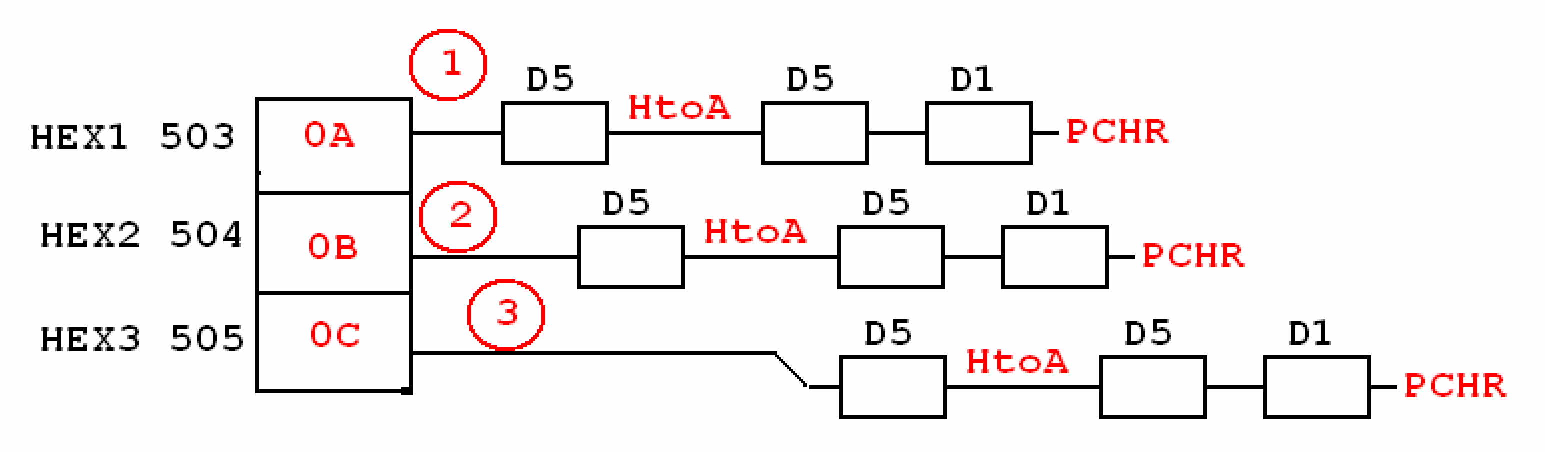
DtoH (subroutine code)



```
;D2H Subroutine
;INPUT: 3 digit dec number
;OUTPUT: 3 digit hex number
;Requirement 1: INPUT must be in DEC1 DEC2 DEC3 memory location
;Requirement 2: D1 D2 D3 are used for this subroutine
;Result: Output hex will be stored at HEX1 HEX2 HEX3 memory location'
DTOH    CLR.L   D2
        CLR.L   D3
        CLR.L   D1
        MOVE.B  DEC1, D2        ;(ex)823 = 8*100 + 2*10 +3
        MULU    #$64, D2
        MOVE.B  DEC2, D3
        MULU    #$0A, D3
        ADD.W   D2,D3
        MOVE.B  DEC3, D1
        ADD.W   D3,D1

        CLR.L   D2
        MOVE.W  D1,D2
        ANDI.W  #$0F00, D2
        LSR.W   #8, D2
        MOVE.B  D2, HEX1
        CLR.L   D2
        MOVE.W  D1, D2
        ANDI.W  #$00F0, D2
        LSR.W   #4,D2
        MOVE.B  D2, HEX2
        CLR.L   D2
        MOVE.B  D1, D2
        ANDI.B  #$0F, D2
        MOVE.B  D2, HEX3
        RTS
```

The Last Step & Overall

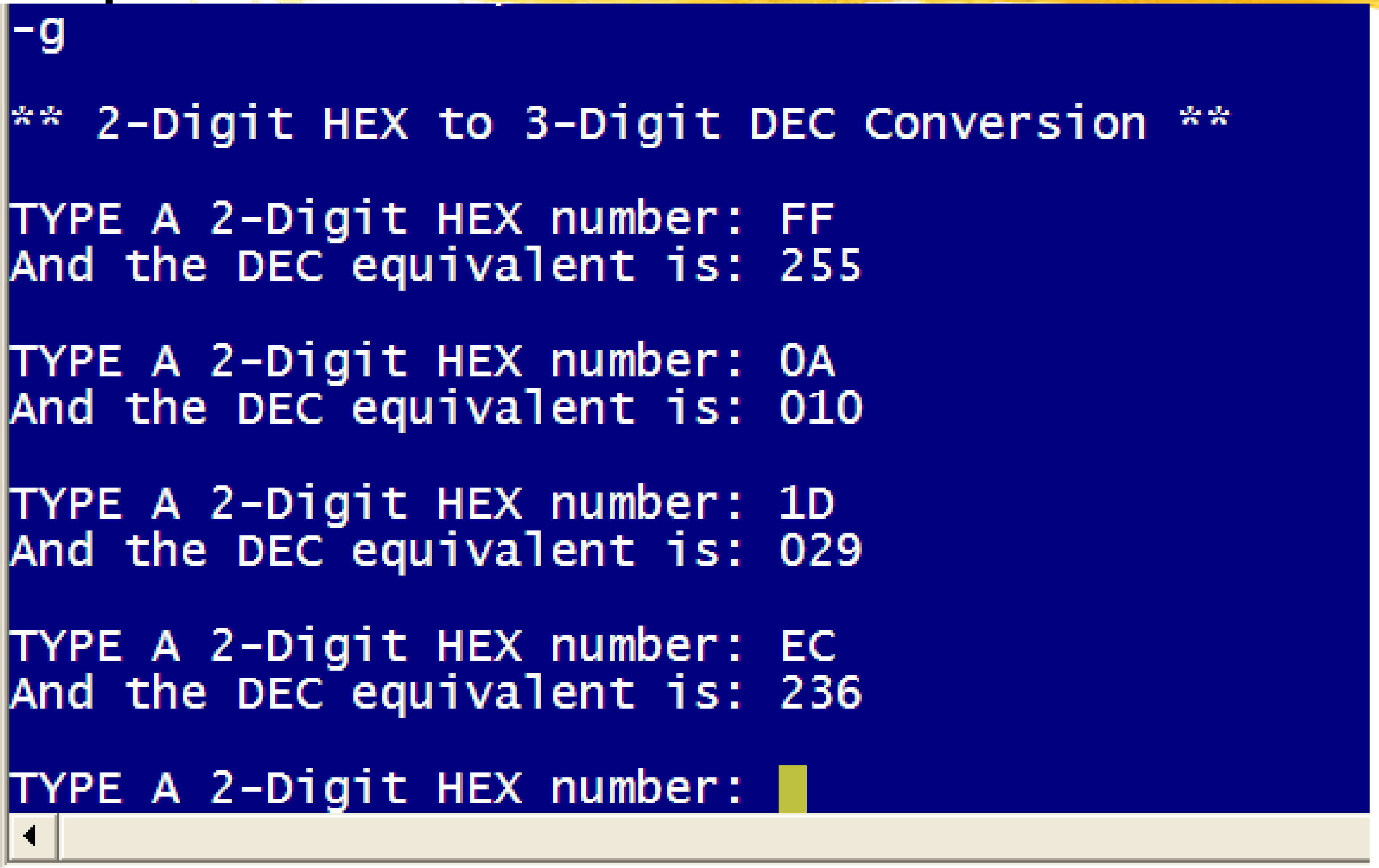
- The last step:
  - Read each Hex byte starting from $503
  - Convert each Hex to ASCII (by calling HtoA subroutine) then Display (by PCHR)



- Overall Structure
  - 1. Pre-Processing
  - 2. Call DtoH subroutine
  - 3. Last Step
- Save File as D2H.X68

EX V: HEX to DEC Conversion

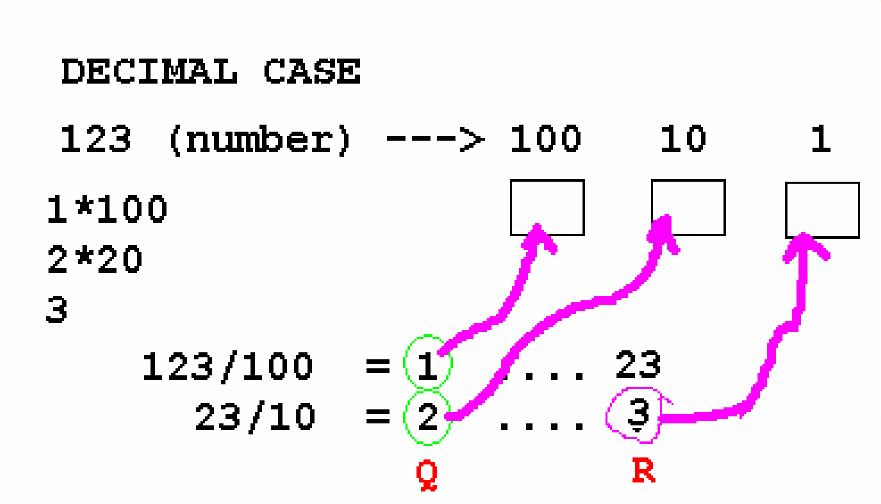
- Sample Run



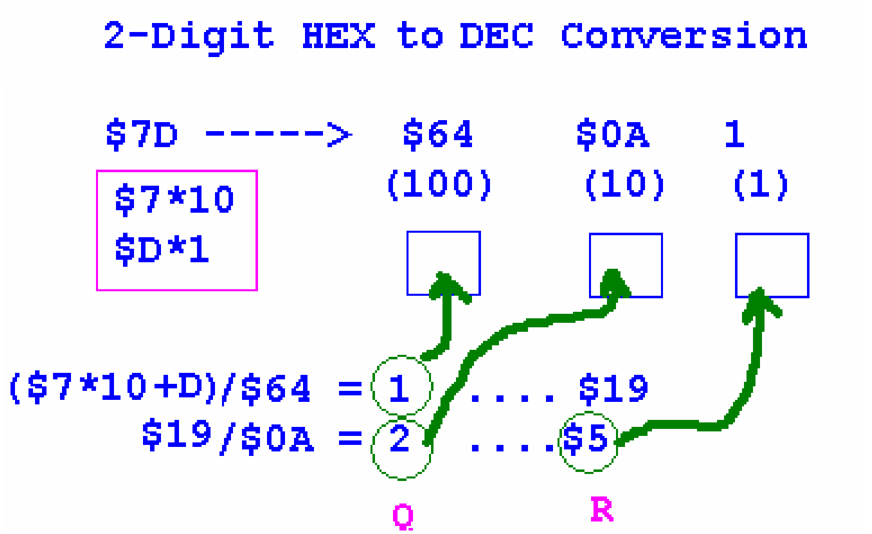
```
-g

** 2-Digit HEX to 3-Digit DEC Conversion **

TYPE A 2-Digit HEX number: FF
And the DEC equivalent is: 255

TYPE A 2-Digit HEX number: 0A
And the DEC equivalent is: 010

TYPE A 2-Digit HEX number: 1D
And the DEC equivalent is: 029

TYPE A 2-Digit HEX number: EC
And the DEC equivalent is: 236

TYPE A 2-Digit HEX number:
```

HEX to DEC conversion

⌘2 Digit HEX to 3 Digit DEC Conversion



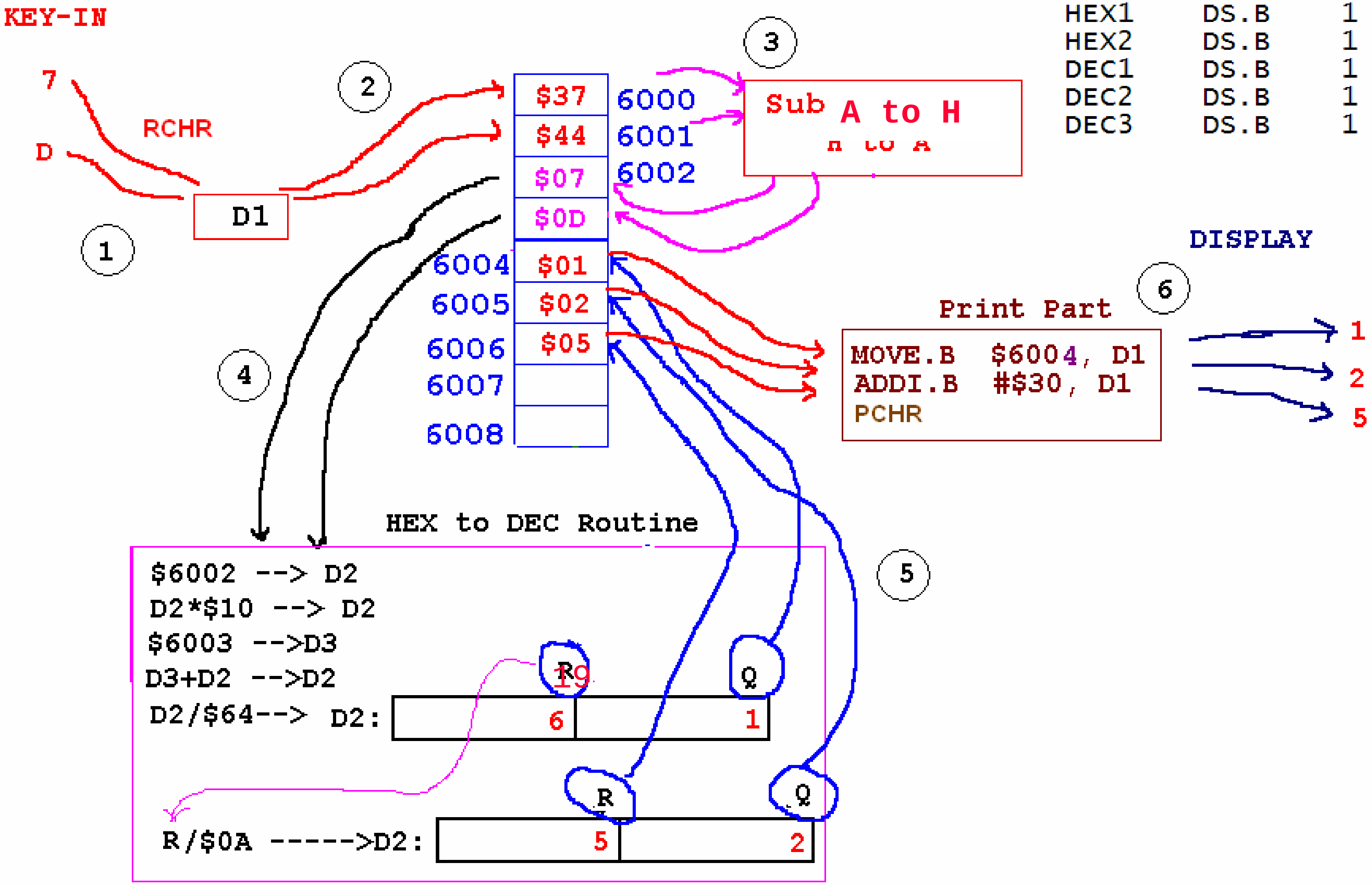
```
DECIMAL CASE

123 (number) ---> 100    10    1

1*100
2*20
3
      123/100  = 1 .... 23
       23/10   = 2 .... 3
                 Q       R
```



```
2-Digit HEX to DEC Conversion

$7D -----> $64     $0A    1
          (100)    (10)   (1)
$7*10
$D*1

($7*10+D)/$64 = 1 .... $19
   $19/$0A    = 2 ....$5
                Q       R
```

HEX to DEC Conversion Scheme

```
        ORG     $6000
ASC1    DS.B    1
ASC2    DS.B    1
HEX1    DS.B    1
HEX2    DS.B    1
DEC1    DS.B    1
DEC2    DS.B    1
DEC3    DS.B    1
```

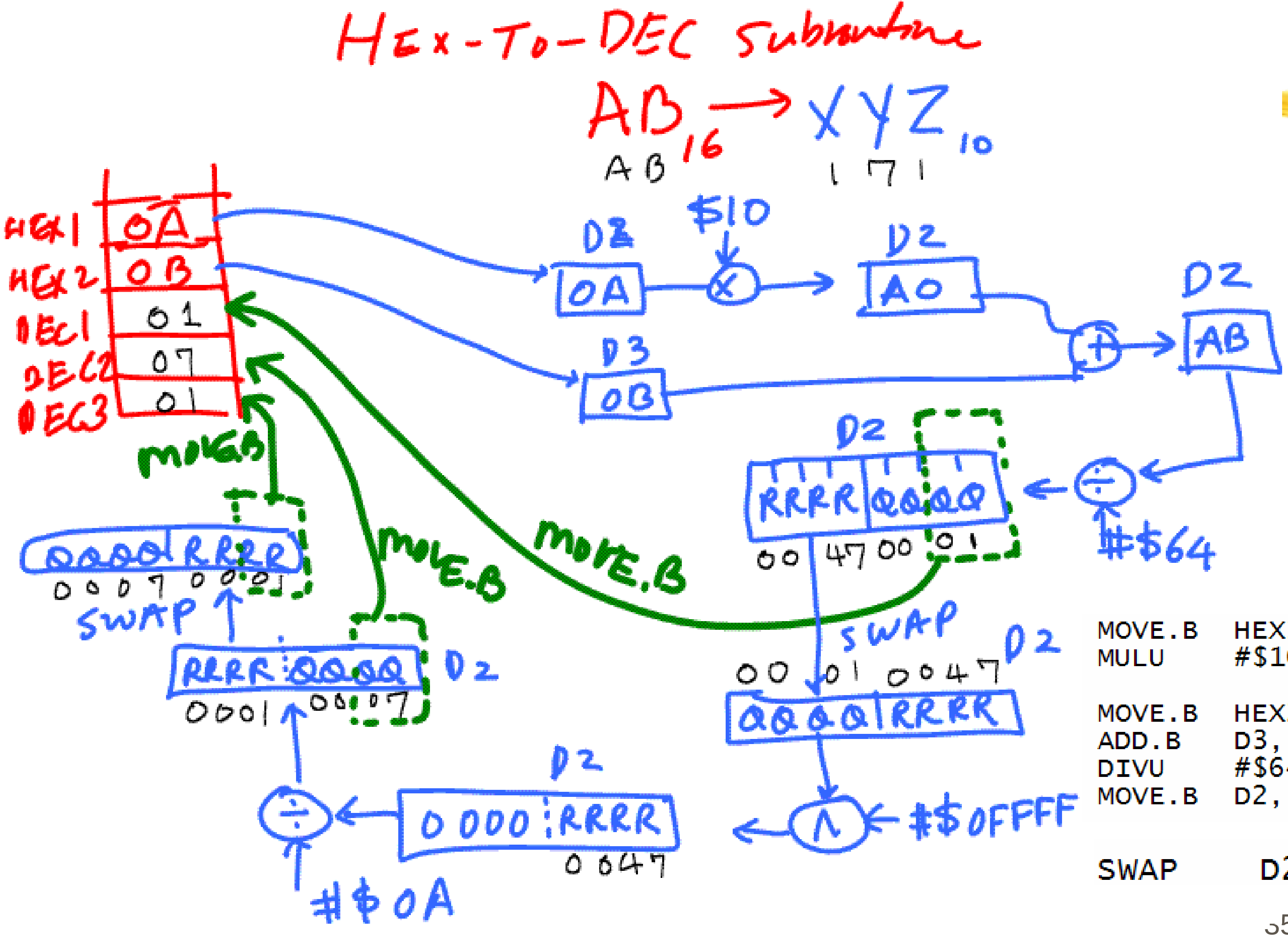


```
MOVE.B  $6004, D1
ADDI.B  #$30, D1
PCHR
```

```
$6002 --> D2
D2*$10 --> D2
$6003 -->D3
D3+D2 -->D2
D2/$64--> D2:
R/$0A ----->D2:
```

HtoD structure

2-digit Hex to 3-digit Dec

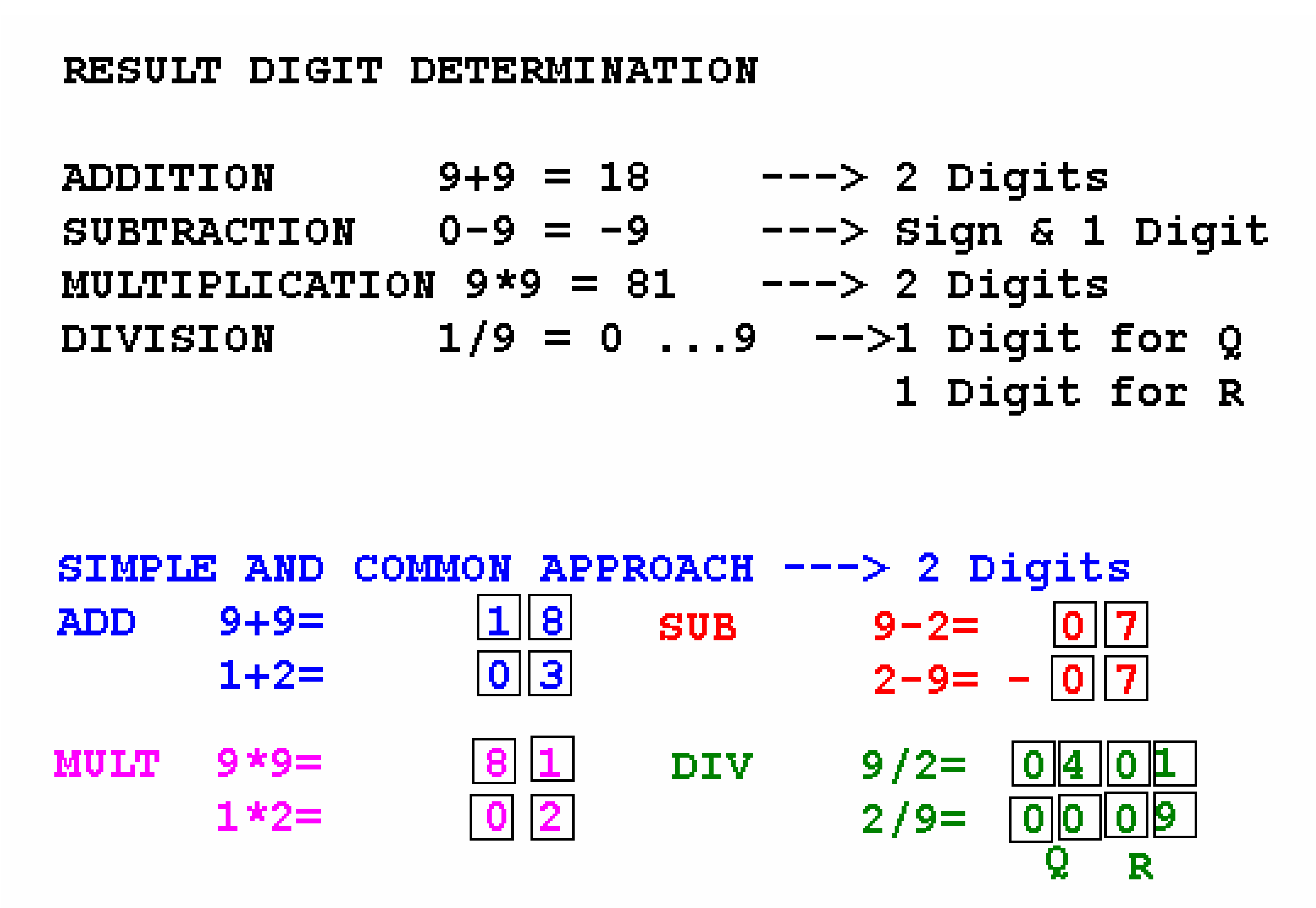


```
MOVE.B   HEX1, D2
MULU     #$10, D2

MOVE.B   HEX2, D3
ADD.B    D3, D2
DIVU     #$64, D2
MOVE.B   D2, DEC1

SWAP     D2
```

EXERCISE VI: Simple Calculator

- Unsigned Single Digit Calculator
  - 1+9 = 10
  - 3+9 = 12
  - 9-3 = 6
  - 3 – 9 = -6
  - 2*4 = 8
  - 9*9 = 81
  - 9/1 = 9
  - 1/9 = 0 --- R

Unsigned 1-Digit DEC calculator



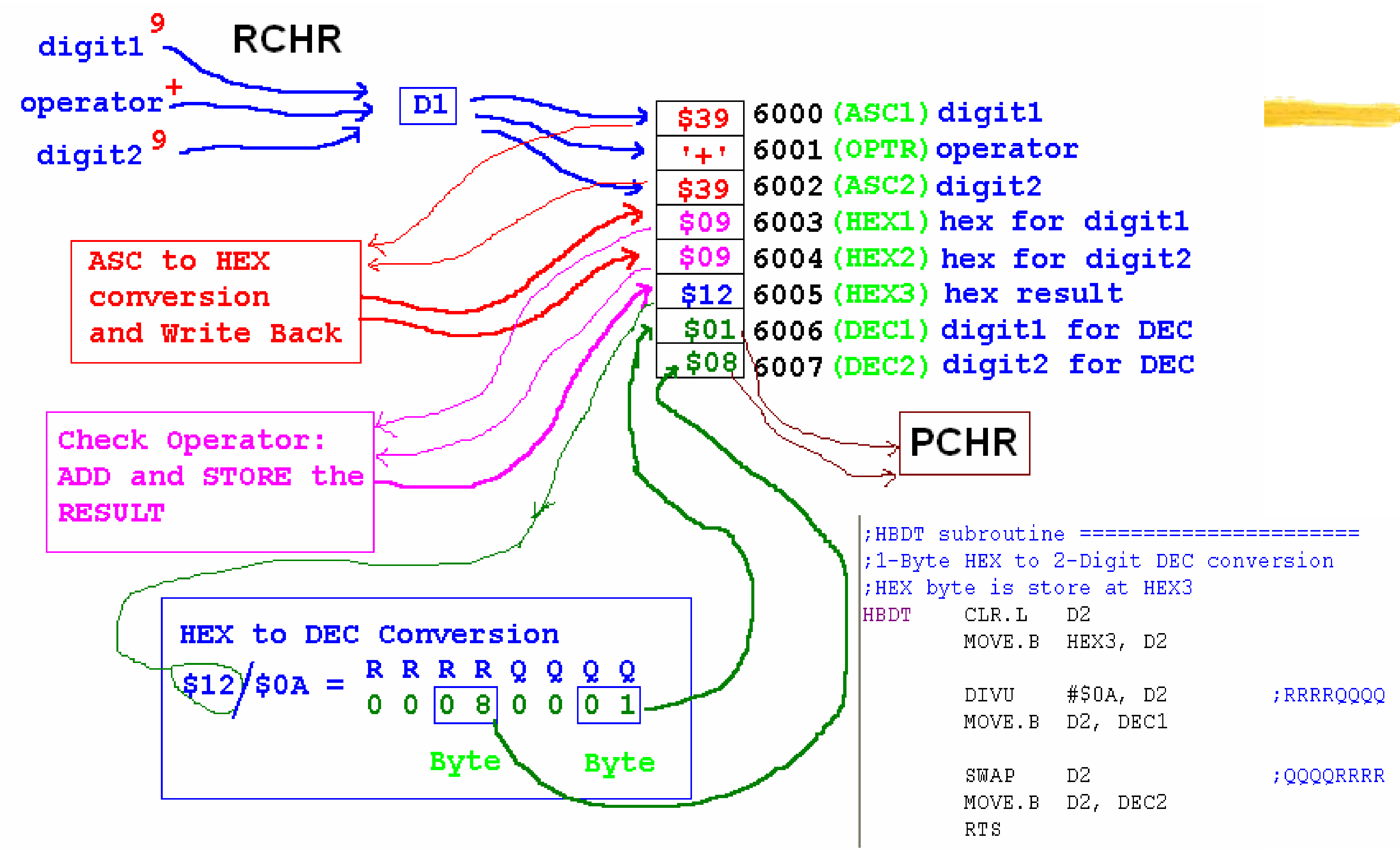
RESULT DIGIT DETERMINATION

```
ADDITION       9+9 = 18     ---> 2 Digits
SUBTRACTION    0-9 = -9     ---> Sign & 1 Digit
MULTIPLICATION 9*9 = 81     ---> 2 Digits
DIVISION       1/9 = 0 ...9  -->1 Digit for Q
                                1 Digit for R
```

SIMPLE AND COMMON APPROACH ---> 2 Digits

```
ADD   9+9=     1 8     SUB    9-2=    0 7
      1+2=     0 3            2-9=  - 0 7

MULT  9*9=     8 1     DIV    9/2=   0 4 0 1
      1*2=     0 2            2/9=   0 0 0 9
                                      Q   R
```

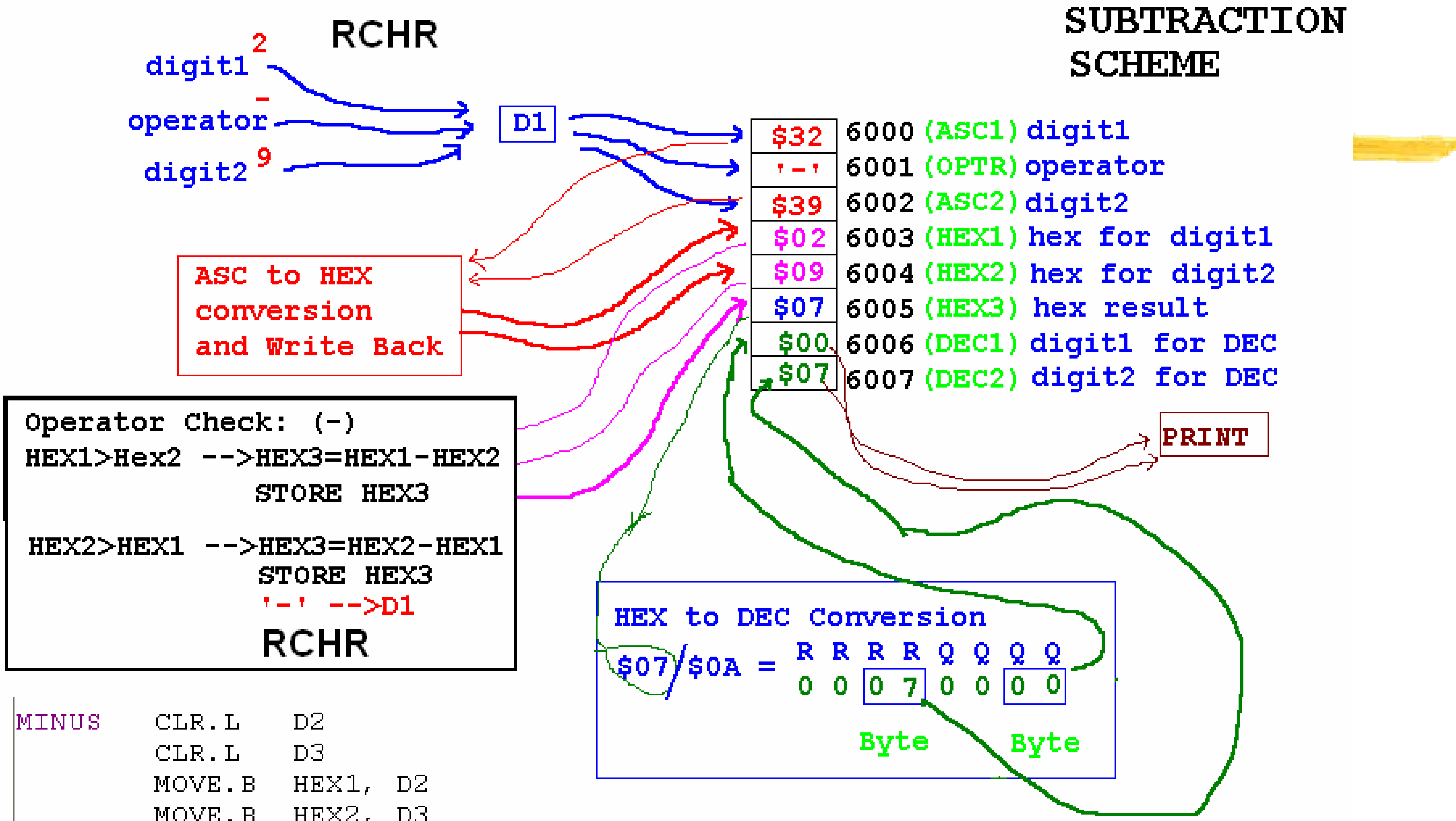
Addition Case



$39	6000	(ASC1)	digit1
'+'	6001	(OPTR)	operator
$39	6002	(ASC2)	digit2
$09	6003	(HEX1)	hex for digit1
$09	6004	(HEX2)	hex for digit2
$12	6005	(HEX3)	hex result
$01	6006	(DEC1)	digit1 for DEC
$08	6007	(DEC2)	digit2 for DEC

```
;HBDT subroutine ======================
;1-Byte HEX to 2-Digit DEC conversion
;HEX byte is store at HEX3
HBDT     CLR.L    D2
         MOVE.B   HEX3, D2

         DIVU     #$0A, D2            ;RRRRQQQQ
         MOVE.B   D2, DEC1

         SWAP     D2                  ;QQQQRRRR
         MOVE.B   D2, DEC2
         RTS
```

Subtraction Case



SUBTRACTION SCHEME

RCHR

$32	6000	(ASC1)	digit1
'-'	6001	(OPTR)	operator
$39	6002	(ASC2)	digit2
$02	6003	(HEX1)	hex for digit1
$09	6004	(HEX2)	hex for digit2
$07	6005	(HEX3)	hex result
$00	6006	(DEC1)	digit1 for DEC
$07	6007	(DEC2)	digit2 for DEC

ASC to HEX conversion and Write Back

PRINT

Operator Check: (-)

HEX1>Hex2 -->HEX3=HEX1-HEX2
STORE HEX3

HEX2>HEX1 -->HEX3=HEX2-HEX1
STORE HEX3
'-' -->D1

RCHR

HEX to DEC Conversion

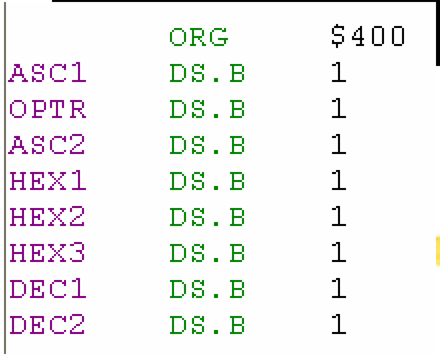
$07/$0A =

R	R	R	R	Q	Q	Q	Q
0	0	0	7	0	0	0	0

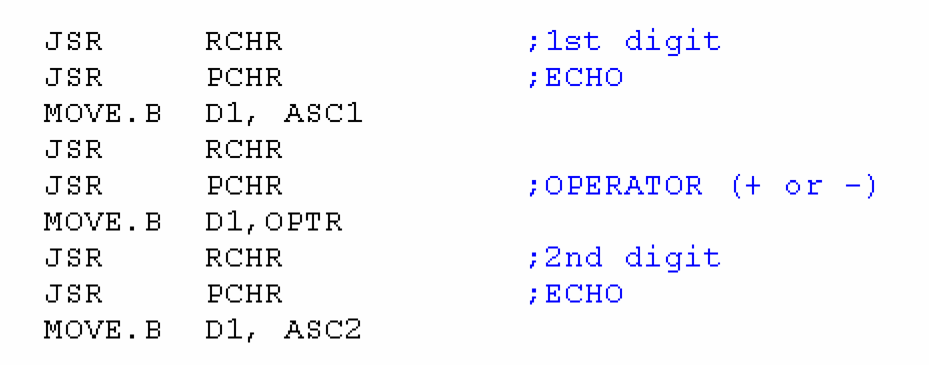
Byte Byte

```
MINUS     CLR.L     D2
          CLR.L     D3
          MOVE.B    HEX1, D2
          MOVE.B    HEX2, D3
          CMP.B     D2, D3
          BGT       SIGN
;Positive Answer
          SUB.B     D3, D2
          MOVE.B    D2, HEX3
          JSR       HBDT
```

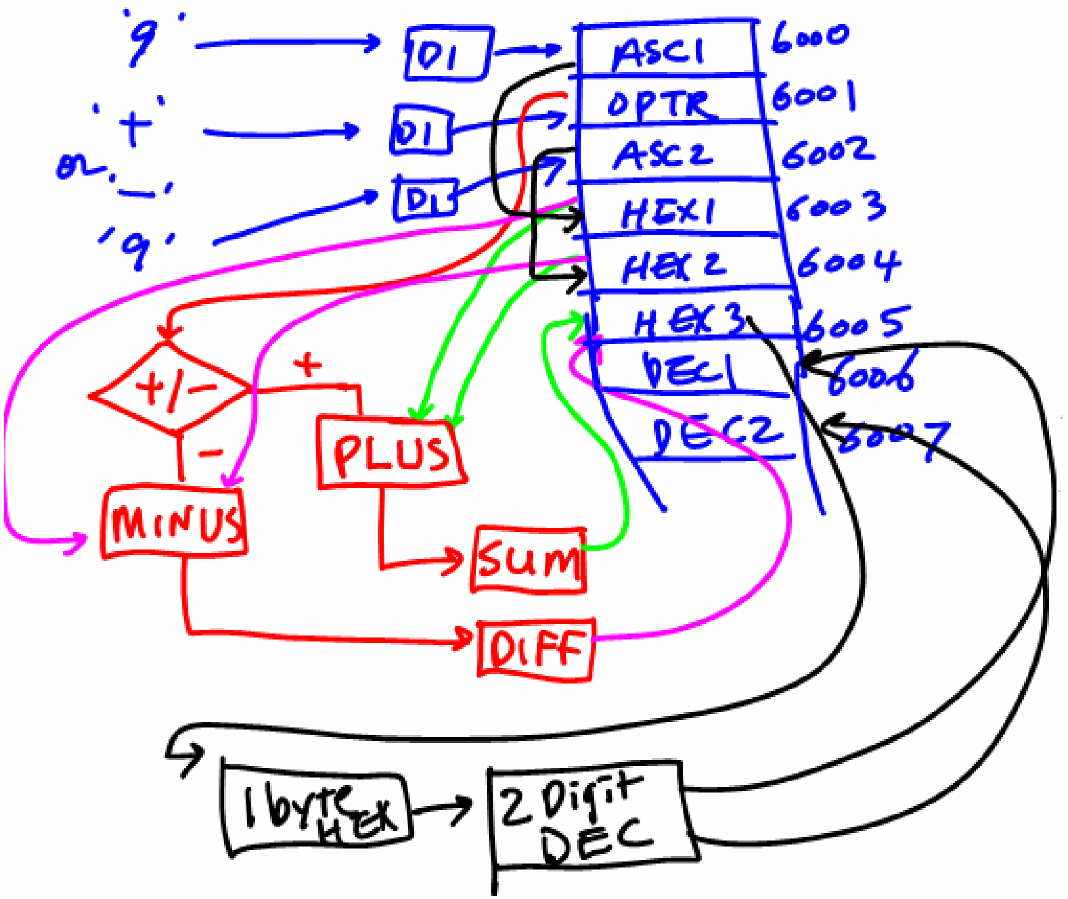
Add-Sub Structure

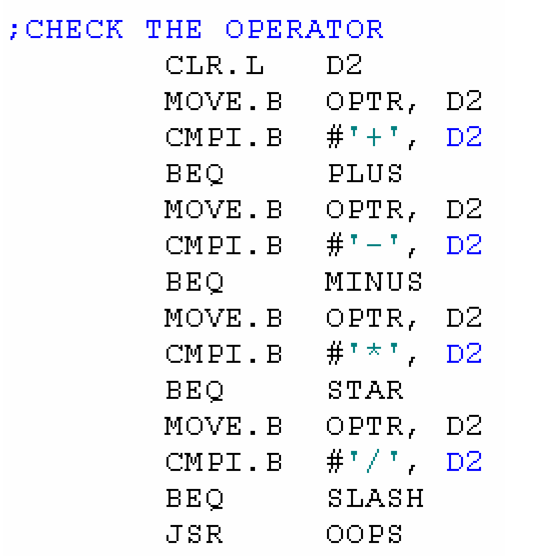


```
        ORG     $400
ASC1    DS.B    1
OPTR    DS.B    1
ASC2    DS.B    1
HEX1    DS.B    1
HEX2    DS.B    1
HEX3    DS.B    1
DEC1    DS.B    1
DEC2    DS.B    1
```



```
JSR     RCHR            ;1st digit
JSR     PCHR            ;ECHO
MOVE.B  D1, ASC1
JSR     RCHR
JSR     PCHR            ;OPERATOR (+ or -)
MOVE.B  D1,OPTR
JSR     RCHR            ;2nd digit
JSR     PCHR            ;ECHO
MOVE.B  D1, ASC2
```

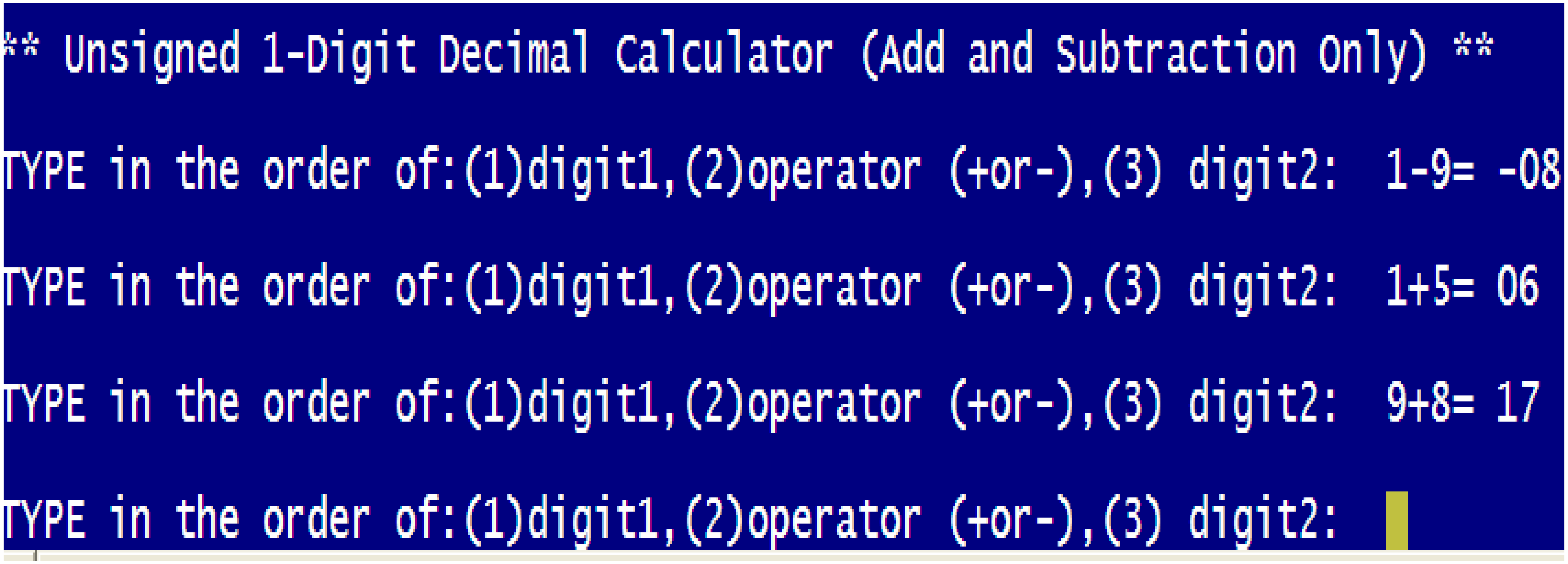




```
;CHECK THE OPERATOR
        CLR.L   D2
        MOVE.B  OPTR, D2
        CMPI.B  #'+', D2
        BEQ     PLUS
        MOVE.B  OPTR, D2
        CMPI.B  #'-', D2
        BEQ     MINUS
        MOVE.B  OPTR, D2
        CMPI.B  #'*', D2
        BEQ     STAR
        MOVE.B  OPTR, D2
        CMPI.B  #'/', D2
        BEQ     SLASH
        JSR     OOPS
```

Addition and Subtraction Only Code

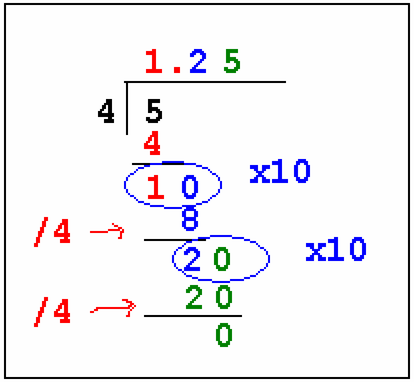
⌘ADDSUB sample run



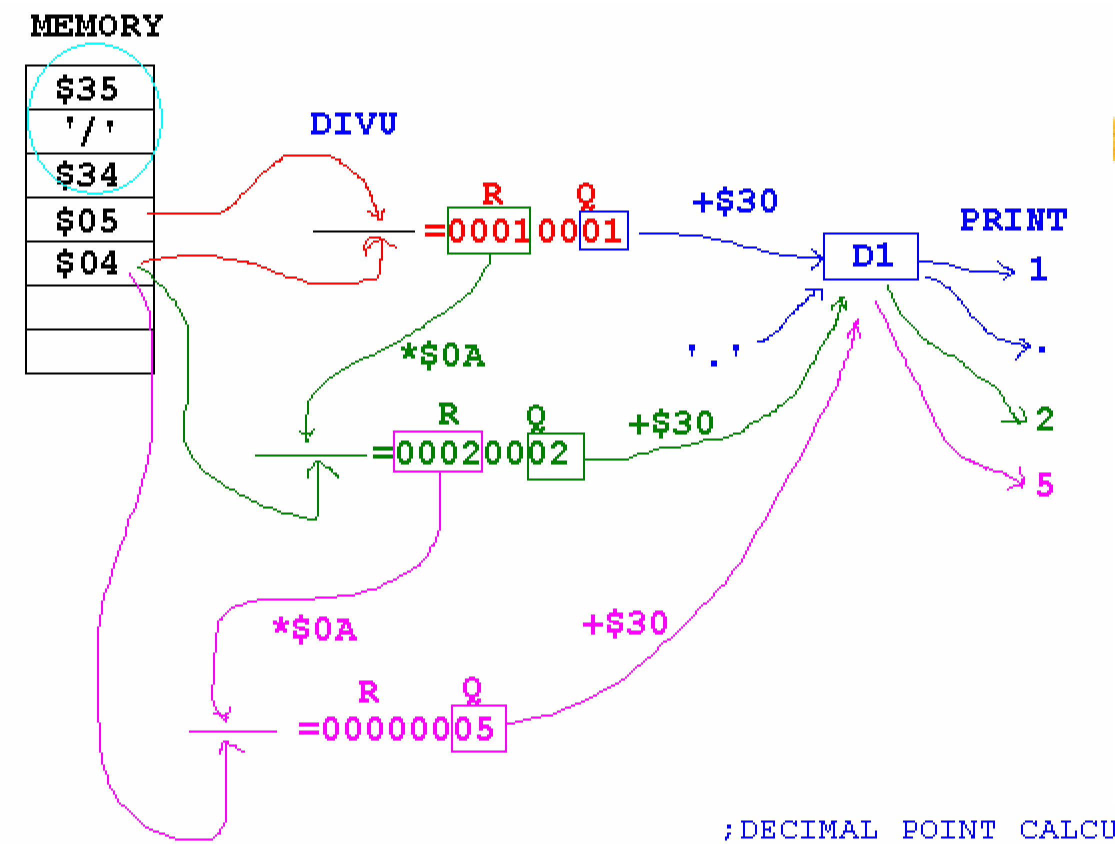
```
** Unsigned 1-Digit Decimal Calculator (Add and Subtraction Only) **

TYPE in the order of:(1)digit1,(2)operator (+or-),(3) digit2:  1-9= -08

TYPE in the order of:(1)digit1,(2)operator (+or-),(3) digit2:  1+5= 06

TYPE in the order of:(1)digit1,(2)operator (+or-),(3) digit2:  9+8= 17

TYPE in the order of:(1)digit1,(2)operator (+or-),(3) digit2:
```

Multiplication and Division

- Multiplication
  - Same as Addition or Division
  - Answer format
    - 2 digit decimal number: (ex) 8*8 = 64 or 9*0=00
- Division
  - The answer format:
    - Up to 2 decimal points
    - (ex) 8/4 = 2.00
    - (ex) 2/8 = 0.25
    - (ex) 5/4 = 1.25



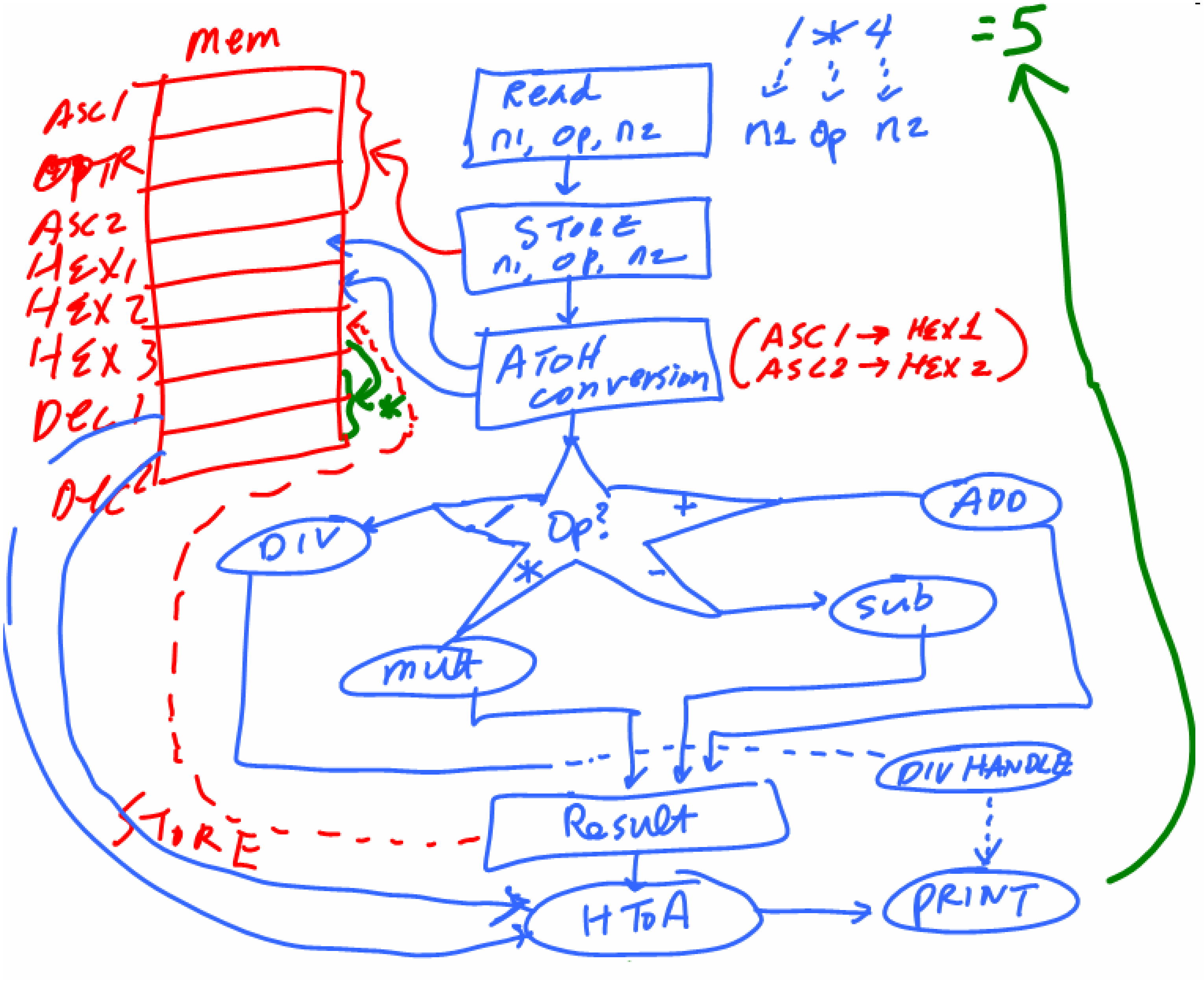
Division Case (decimal point)



```
;====for DIVISION ONLY ===
SLASH    CLR.L    D2
         CLR.L    D3
         MOVE.B   HEX1,D2
         MOVE.B   HEX2,D3
;        TRAP     #9
         DIVU     D3,D2
         MOVE.B   D2, DEC2
         MOVE.B   DEC2, D5
         JSR      HtoA
         MOVE.B   D5, D1
         JSR      PCHR
         MOVE.B   #'.', D1
         JSR      PCHR
```

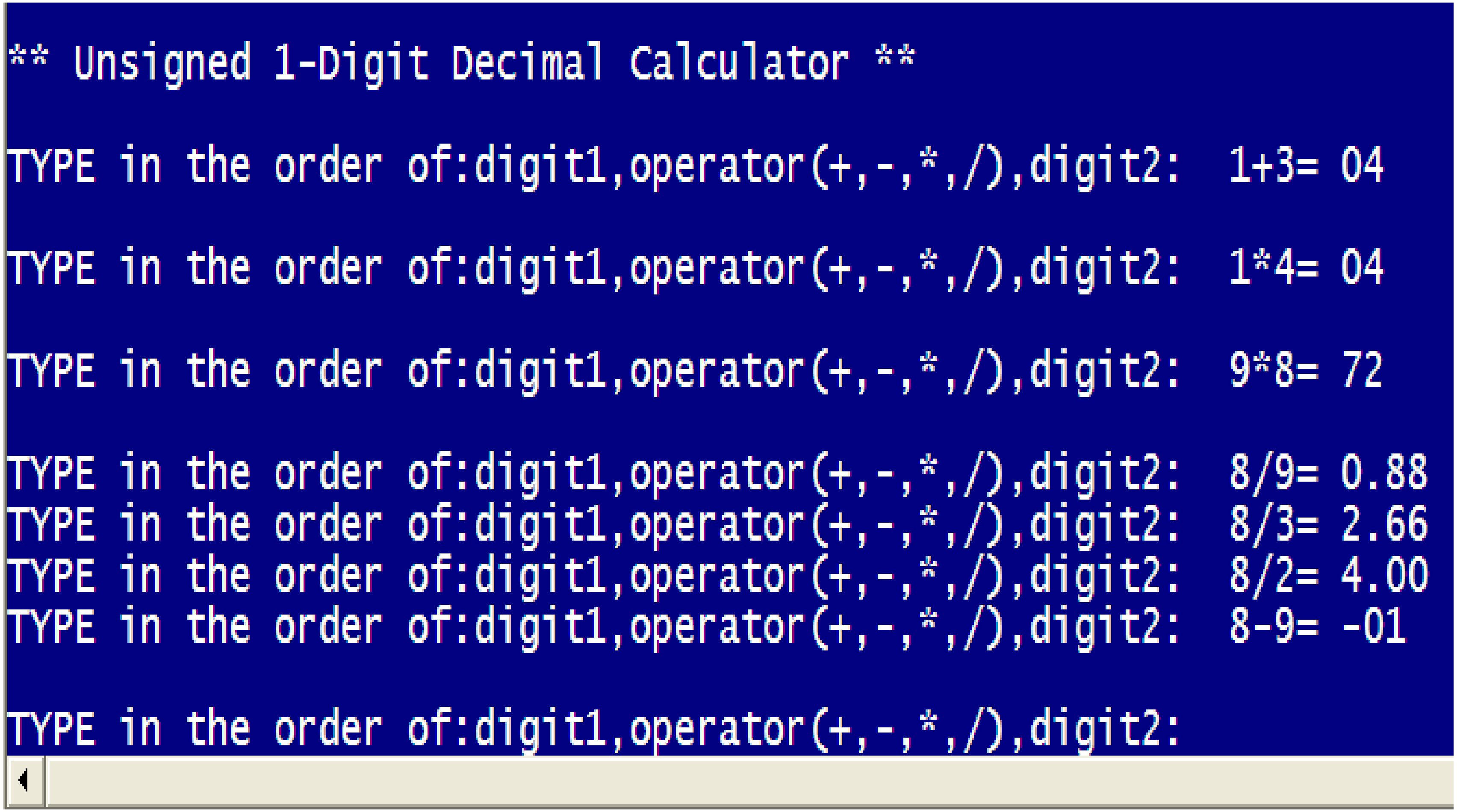
```
;DECIMAL POINT CALCULATION
        SWAP     D2                      ;
        ANDI.L   #$000000FF, D2
        MULU     #$0A, D2
        DIVU     D3, D2    ;RRRRQQQQ
        MOVE.B   D2, D1
        ADDI.B   #$30,D1
        JSR      PCHR
```

Code Structure



Complete single digit Calculator

- Sample Run



```
** Unsigned 1-Digit Decimal Calculator **

TYPE in the order of:digit1,operator(+,-,*,/),digit2:  1+3= 04

TYPE in the order of:digit1,operator(+,-,*,/),digit2:  1*4= 04

TYPE in the order of:digit1,operator(+,-,*,/),digit2:  9*8= 72

TYPE in the order of:digit1,operator(+,-,*,/),digit2:  8/9= 0.88
TYPE in the order of:digit1,operator(+,-,*,/),digit2:  8/3= 2.66
TYPE in the order of:digit1,operator(+,-,*,/),digit2:  8/2= 4.00
TYPE in the order of:digit1,operator(+,-,*,/),digit2:  8-9= -01

TYPE in the order of:digit1,operator(+,-,*,/),digit2:
```

CODING PROJECT

- Unsigned 2-digit decimal calculator (50+ pts)
- PROJECT SUBMISSION
  - Description of the project (“PJT_lastname.doc”) (10)
    - Program Design
    - Include graphical description of the overall code structure
  - Code with plenty of comments (almost every line of instruction) (“CALC2D_lastname.X68”) (40+extra)
  - Deadline: 11:59pm, Wed 21 OCT 09
  - Electronic Submission
- Extra Point Distribution
  - 10: First correct code arrived
  - 5: Second and third correct codes arrived