Lecture 6

First Instructions

Code Composer Studio

Starting today, we will need CCS – not necessarily in class

but for all assignments from now on

Posted a guide on how to install CCS – Find it under Resources in Carmen

Code Composer Studio Download Instructions

- Go to https://www.ti.com/tool/CCSTUDIO
  - Or type "Code Composer Studio Download" into your search engine and navigate to the first result
- Go to the **Downloads** section and select **Download Options**

- Select the installer for whichever operating system your machine is running (web installer is recommended because the offline installer is a very large download)

CCS does not work on tablets (iPad etc.)

You can use ECE Windows Computing Labs – all machines have CCS

https://ets.osu.edu/labs

Code Composer Studio

Code Composer Studio is an **Integrated Development Environment (IDE)**

We will use CCS to

- Write/edit assembly language programs
- Compile/build assembly language programs into machine language code
- Load the code into the FRAM of the MCU
- Debug the program as it runs in the CPU
  - Single step the program
  - Set breakpoints
  - View memory locations: core registers, RAM, FRAM etc.

Assembly Language

A typical line of assembly language has four parts

```
StopWDT:    mov.w   #WDTPW|WDTHOLD,&WDTCTL  ;Stop watchdog timer
```

Label **Operation** **Operands** **Comment**

Label: starts in the first column and may be followed by a colon (:) optional

Operation: **instruction** for CPU or **assembler directive**

Operands: data needed for the operation, nature depends on the operation

Comment: the rest of the line, following a semicolon (;)
assembler skips comments, but critical for the programmer

Coding Style Guidelines

TI recommended coding style guidelines for assembly are

```
StopWDT:    mov.w   #WDTPW|WDTHOLD,&WDTCTL  ; Stop watchdog
                                            ; timer
```

Column 1 13 21 **MACROS** 45

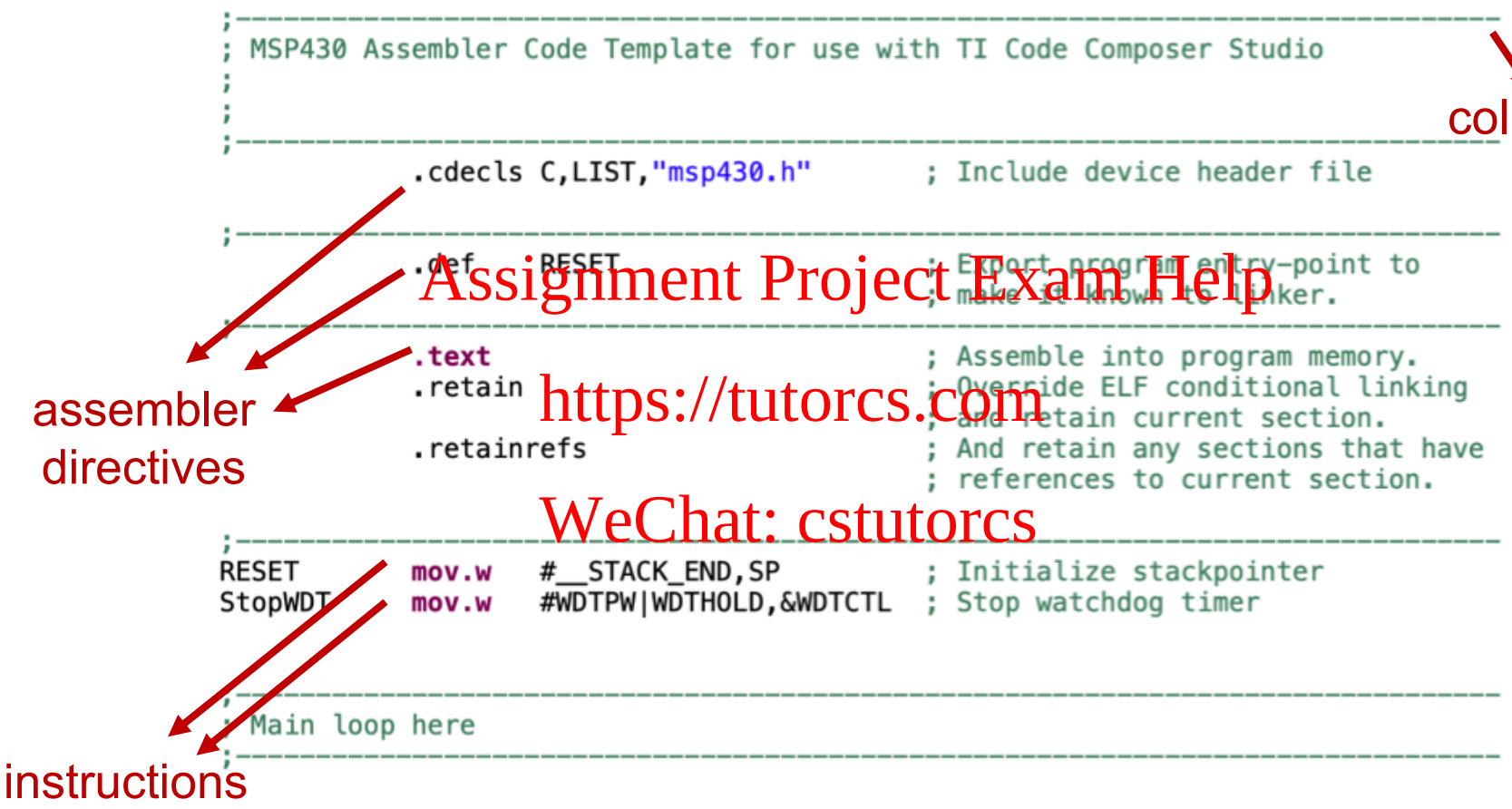
1. No line should exceed 80 characters
2. **Use macros provided in the MSP430 header file**
3. **Labels start in column 1** (and are 10 characters or fewer) **Critical!**
4. **Operators start in column 13**
5. **Operands start in column 21**

Please follow

6. Comments start in column 45, the first word is capitalized
7. For multiline comments, additional lines are not capitalized

Comments are very important, but format can be more flexible

MSP430 Assembler Code Template




```
;-------------------------------------------------------------------------------
; MSP430 Assembler Code Template for use with TI Code Composer Studio
;
;
;-------------------------------------------------------------------------------
            .cdecls C,LIST,"msp430.h"       ; Include device header file

;-------------------------------------------------------------------------------
            .def    RESET                   ; Export program entry-point to
                                            ; make it known to linker.
;-------------------------------------------------------------------------------
            .text                           ; Assemble into program memory.
            .retain                         ; Override ELF conditional linking
                                            ; and retain current section.
            .retainrefs                     ; And retain any sections that have
                                            ; references to current section.

;-------------------------------------------------------------------------------
RESET       mov.w   #__STACK_END,SP         ; Initialize stackpointer
StopWDT     mov.w   #WDTPW|WDTHOLD,&WDTCTL  ; Stop watchdog timer


;-------------------------------------------------------------------------------
; Main loop here
;-------------------------------------------------------------------------------


;-------------------------------------------------------------------------------
; Stack Pointer definition
;-------------------------------------------------------------------------------
            .global __STACK_END
            .sect   .stack
```

MSP430 Header File - Macros

```
1 ;-------------------------------------------------------------------------------
2 ; MSP430 Assembler Code Template for use with TI Code Composer Studio
3 ;
4 ;
5 ;-------------------------------------------------------------------------------
6             .cdecls C,LIST,"msp430.h"       ; Include device header file
7
```

Search for "**msp430fr69891.h**" on your computer


```
sfr_w(WDTCTL);                          /* Watchdog Timer Control */
sfr_b(WDTCTL_L);                        /* Watchdog Timer Control */
sfr_b(WDTCTL_H);                        /* Watchdog Timer Control */
/* The bit names have been prefixed with "WDT" */
/* WDTCTL Control Bits */
#define WDTIS0                  (0x0001)        /* WDT - Timer Interval Select 0 */
#define WDTIS1                  (0x0002)        /* WDT - Timer Interval Select 1 */
#define WDTIS2                  (0x0004)        /* WDT - Timer Interval Select 2 */
#define WDTCNTCL                (0x0008)        /* WDT - Timer Clear */
#define WDTTMSEL                (0x0010)        /* WDT - Timer Mode Select */
#define WDTSSEL0                (0x0020)        /* WDT - Timer Clock Source Select 0 */
#define WDTSSEL1                (0x0040)        /* WDT - Timer Clock Source Select 1 */
#define WDTHOLD                 (0x0080)        /* WDT - Timer hold */
#define WDTPW                   (0x5A00)
```

```
mov.w   #WDTPW|WDTHOLD,&WDTCTL  ;Stop watchdog timer
```

MACROS

| is logic OR

The Move Instruction

The **move instruction** *copies* a byte or word specified in the source to the destination

```
mov.w    source, destination    ← copies a word
mov.b    source, destination    ← copies a byte
```

Operation **Operand1** **Operand2**

The source is not affected by this operation – copy rather than move

If the suffix (i.e., `.w` or `.b`) is omitted, the default is `mov.w`

Best practice is to always explicitly specify the suffix

There are several options to specify the `source` and `destination`

⇒ **Addressing modes**

Addressing Modes

At this point we will look at three modes – more will follow

- **Immediate data** using **#**

  The value (byte or word) is given after #

- **Absolute address** using **&**

  The absolute address of the byte or word is given after &

- **Register mode** using **R**

  The source/destination is one of the core registers R0 – R15

e.g.:

```
mov.w   #WDTPW|WDTHOLD,   &WDTCTL
```

Immediate — `#0x5A80`

Absolute — `&0x051C` — address of watchdog control register

Addressing Modes

e.g.:

```
;-------------------------------------------------------------------------------
; MSP430 Assembler Code Template for use with TI Code Composer Studio
;
;-------------------------------------------------------------------------------
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;-------------------------------------------------------------------------------
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                                            ; make it known to linker.
;-------------------------------------------------------------------------------
            .text                           ; Assemble into program memory.
            .retain                         ; Override ELF conditional linking
                                            ; and retain current section.
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;-------------------------------------------------------------------------------
RESET       mov.w   #__STACK_END,SP         ; Initialize stackpointer
StopWDT     mov.w   #WDTPW|WDTHOLD,&WDTCTL  ; Stop watchdog timer

;-------------------------------------------------------------------------------
; Main loop here
;-------------------------------------------------------------------------------


;-------------------------------------------------------------------------------
; Stack Pointer definition
;-------------------------------------------------------------------------------
            .global __STACK_END
            .sect   .stack
```

Addressing Modes

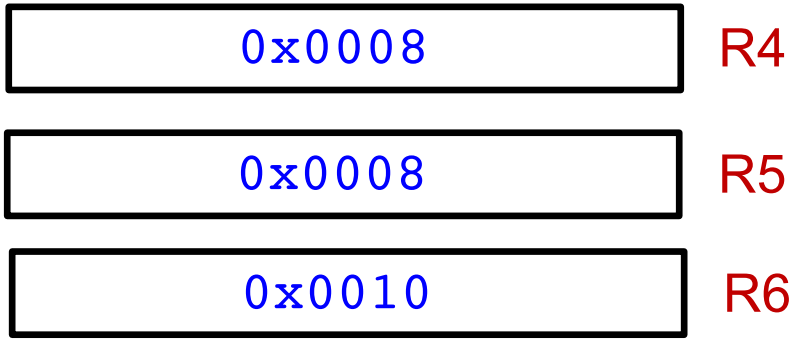
```
mov.w    source,  destination
mov.b    source,  destination
```

Immediate #
Absolute &
Register R

Absolute &
Register R

Immediate values can be **binary**, **hexadecimal** or **decimal**

```
mov.b   #00001000b, R4
mov.b   #0x8, R5
mov.b   #16, R6
```



Addressing Modes

e.g.:

```
mov.w   R4, R5
```
copy contents of R4 to R5

```
mov.w   R4, &0x1C00
```
copy contents of R4 to memory location with address 0x1C00

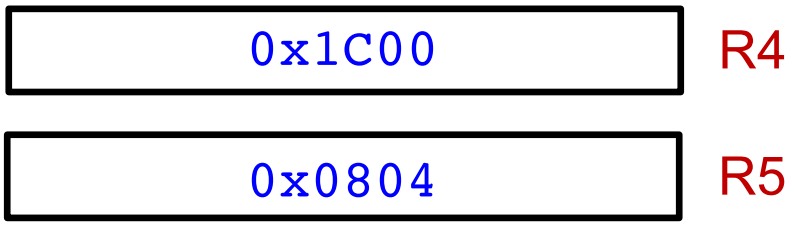

```
mov.w   #0x0804, &0x1C00
```
copy value 0x0804 to memory location with address 0x1C00

Popquiz


```
mov.w   #0x0804, &0x1C00

mov.w   #0x1C00, R4

mov.w   &0x1C00, R5
```



Basic Arithmetic: add

The **add** instruction adds the *source* to the *destination*

```
destination += source
```

```
mov.w    source,  destination
mov.b    source,  destination
```

Immediate # Absolute & Register R

Absolute & Register R

Basic Arithmetic: `rra`

The **`rra`** instruction shifts all bits one position to the right and fills the void by replicating the most significant bit

`rra` is short for roll right arithmetic

and corresponds to dividing a signed number by 2

The **`rra`** instruction takes only one operand


```
rra.w    dst
rra.b    dst
```

Absolute & Register R

Division by a Power of Two

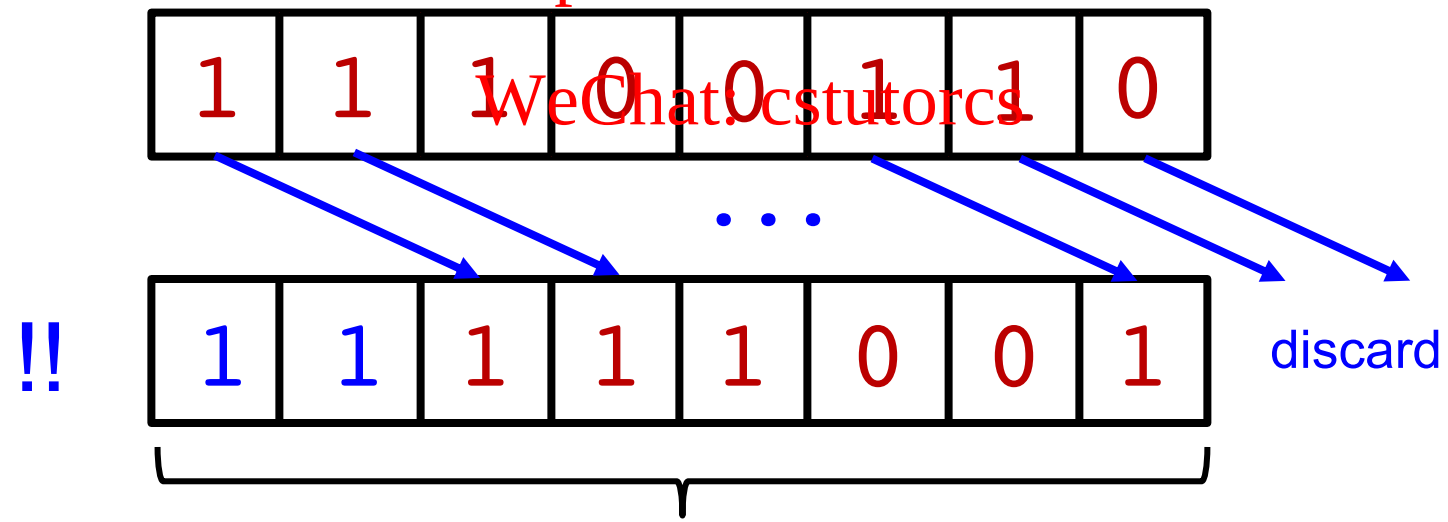
To divide a **signed number** by 2^m

- **Shift m-bits to the right & pad with the most significant bit "sign bit"**
- The answer will not be exact – we are discarding the fractional part

taking the floor function: $\lfloor -6.5 \rfloor = -7$

e.g.: –26 ÷ 4 $\quad 4 = 2^2 \Rightarrow$ Shift 2 bits to the right


```
rra.b    dst
rra.b    dst
```



249 in decimal $\Rightarrow$ **- 7**

The Infinite Loop

At the end of (almost) every program we write we will add an infinite loop

```
loop:   jmp   loop
```

Unconditionally jump to the label loop and continue to execute instructions from that point on

Label **Instruction**

Prevents the program counter (PC) from proceeding to the next word written in FRAM and executing the random data in there

The compiler gives a warning when the last instruction of a program is a jump

Hence, we will follow with a `nop` – an operation that does nothing

Until next notice, every program we write will end with

```
loop:   jmp   loop
        nop
```

You can use a different label name