Homework 1

Name: PATHRI VIDYA PRAVEEN
Roll No.: CS24BTECH11047
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1. Write assembly instruction to achieve given functionality:

a. $x8 = x5 - 5$

Ans: $\boxed{\text{addi } x8,\ x5,\ -5}$

Explanation: addi ~~adds~~ instruction adds immediate (−5 here) to register x5 and store it in register x8. Subtracting 5 is same as adding −5.

b. $x5 = x3 * 8$

Ans: $\boxed{\text{slli } x5,\ x3,\ 3}$

Explanation: Multiplying x3 by 8 is same as doing left shift by 3 bits (As $2^3 = 8$), so we do this with slli instruction and store it in x5.

c. $x19 += x10$

Ans: $\boxed{\text{add } x19,\ x19,\ x10}$

Explanation: $x19 = x19 + x10$.
Add values in registers x19, x10 using add instruction and store result in x19.

d. $++x15$

Ans: $\boxed{\text{addi } x15,\ x15,\ 1}$

Explanation: $x15 = x15 + 1$. ~~Add~~ addi instruction adds immediate (1) to register content x15 and store it in x15.

e. $x9 = x15/4$

Ans: $\boxed{\text{srli } x9, x15, 2}$ ($x15$ has unsigned int)

Explanation: (Assume unsigned division). Dividing by 4 is equivalent to right shifting by 2. So, we use srli instruction for this.

$\boxed{\text{srai } x9, x15, 2}$ ($x15$ has signed int)

Explanation: (Assume signed division) Similar to srli but here using srai instruction, we perform division by 2^n ($4 = 2^2$) preserving the sign

f. $x12 = x19 + 24$

Ans: $\boxed{\text{addi } x12, x19, 24}$

Explanation: addi instruction adds immediate value 24 to x19 register content and stores it in x12.

2. Consider array M of 8 byte integers. Base address of M is stored in register x5.

a. M[12] = M[20] + 100

Ans: ~~ld x6, 160(x5~~

ld x6, 160(x5) # x6 = M[20]

addi x6, x6, 100 # x6 = M[20] + 100

sd x6, 96(x5) # M[12] = x6 = M[20]+100

b. M[20]++ # x6 = M[20]

Ans: ld x6, 160(x5) # x6 = M[20]+1

addi x6, x6, 1 # M[20] = x6 = M[20]+1

sd x6, 160(x5)

c. swap M[5] and M[12]

(~~Pseudocode: temp = M[5]~~
~~M[5] = M[12]~~
~~M[12] = temp~~) (temp1 = M[5], temp2 = M[12], store temp1 in M[12], temp2 in M[5] address)

Ans:
```
ld x6, 40(x5)     # x6 = temp1 = M[5]
ld x7, 96(x5)     # x7 = M[12] = temp2
sd x7, 40(x5)     # M[5] = temp2
sd x6, 96(x5)     # M[12] = temp1
```

d. Make the 1st 32-bits from MSB side of M[4] as 0

Ans:
```
ld x6, 32(x5)     # x6 = M[4]
# 'And' it with no. 00---0 (32 bits) 11---1 (32 bits)
# to set 1st 32 bits to 0
# Can't use andi because we have to use 12-bit immediate
# So, try to use and instruction
addi x7, x0, -1   # x7 = 0xFFFFFFFF----F (all 1s)
srli x7, x7, 32   # make all zeros to right and shift
and x6, x6, x7    # Make upper 32 bits 0
sd x6, 32(x5)     # stores back
```

e. Swap most significant 32-bits of M[2] with its least significant 32-bits.

Ans:
```
ld x6, 16(x5)     # x6 = M[2] = AB
# let M[2] = AB where A = 1st 32 bits (most significant)
# and B is next 32 bits (least significant)
slli x7, x6, 32   # x7 = B0 -> all 32 '0' bits
srli x8, x6, 32   # x8 = 0A -> 32 '0' bits
or x6, x7, x8     # x6 = BA (swapped)
sd x6, 16(x5)     # store back
```

3. Write following decimal numbers in their 2's complement represent using 8 bit's.

a. +23

Sol: $+23 = 1\times2^4 + 0\times2^3 + 1\times2^2 + 1\times2^1 + 1\times2^0$

$= 16 + 0 + 4 + 2 + 1$

$\Rightarrow$ Valid in range of -128 to 127 and positive

$\Rightarrow +23 \longrightarrow \boxed{00010111}$

b. −1

Sol: $+1 = 00000001$ (binary)

One's complement of $+1 = 11111110$ (toggled all bits)

$\Rightarrow -1 =$ Add 1 to one's complement

$= 11111110 + 1$

$\Rightarrow -1 \longrightarrow \boxed{11111111}$

c. +255

Sol: $\Rightarrow$ Valid range for signed int with 8 bits is -2^7 to 2^7-1 i.e -128 to $+127$

$\Rightarrow$ So, $+255$ is out of range for 8-bit and is not representable 2's complement

d. −128

Sol: $\Rightarrow$ Valid range it is -128 to 127, of binary

$\Rightarrow -128$ has a specific value

$\Rightarrow -128 \longrightarrow \boxed{10000000}$

~~($-128 = 256 - 128$)~~

4. Write the equivalent decimal number for given numbers in 2's complement format.

a. 11010100

Sol: ⇒ MSB is 1 ⟶ no. is negative.

⇒ Invert ⟶ 0010 1011

⇒ Add 1 ⟶ 00101100

⇒ Convert to decimal

$\longrightarrow 1\times 2^2 + 1\times 2^3 + 1\times 2^5 = 32+8+4 = 44$

⇒ 11010100 ⟶ $\boxed{-44}$

[~(11010100) +1]

b. 00101011

Sol: ⇒ MSB is 0 ⟶ no. is positive

$\Rightarrow 1\times 2^0 + 1\times 2^1 + 1\times 2^3 + 1\times 2^5$

$= 1+2+8+32 = 43$

⇒ 00101011 ⟶ $\boxed{+43}$

c. 11111110

Sol: ⇒ MSB is 1 ⟶ no. is negative

⇒ Invert ⟶ 00000001

⇒ Add 1 ⟶ 00000001 +1

= 00000010

⇒ Convert to decimal

$\longrightarrow 1\times 2^1 = 2$

⇒ 11111110 ⟶ $\boxed{-2}$

[– (~(11111110) +1)]