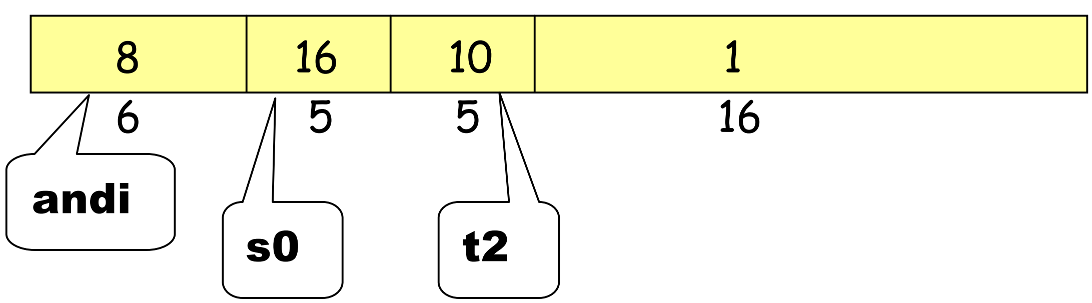
Using AND for bit manipulation

To check if a register $s0 contains an odd number, AND it with a mask that contains all 0's except a 1 in the LSB position, and check if the result is zero (we will discuss decision making later)

andi $t2, $s0, 1

This uses **I-type format** (why?):



Now we have to test if $t2 = 1 or 0

<u>**Making decisions**</u>

if (i == j) then f = g + h; else f = g - h

Use **bne** = branch-nor-equal, **beq** = branch-equal, and **j** = jump

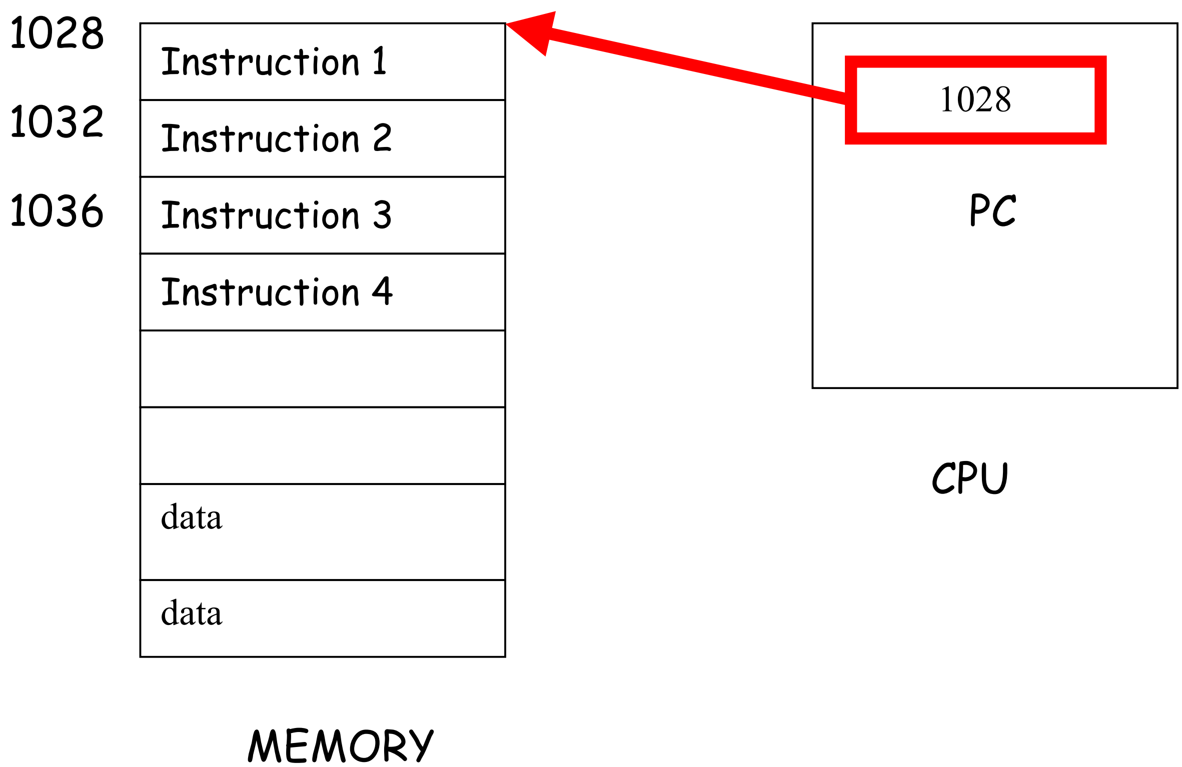
Assume that f, g, h, are mapped into $s0, $s1, $s2

i, j are mapped into $s3, $s4

```
        bne $s3, $s4, Else      # goto Else when i=j
        add $s0, $s1, $s2       # f = g + h
        j    Exit               # goto Exit
Else:   sub $s0, $s1, $s2       # f = g – h
Exit:
```

The program counter and control flow

Every machine has a **program counter** (called PC) that points to the next instruction to be executed.



Ordinarily, PC is incremented by 4 after each instruction is executed. A branch instruction alters the flow of control by modifying the PC.

Compiling a while loop

while (A[i] == k)   i = i + j;

Initially \$s3, \$s4, \$s5 contains i, j, k respectively.

Let \$s6 store the base of the array A. Each element of A is a 32-bit word.

```
Loop:   add $t1, $s3, $s3     # $t1 = 2*i
        add $t1, $t1, $t1     # $t1 = 4*i
        add $t1, $t1, $s6     # $t1 contains address of A[i]
        lw $t0, 0($t1)        # $t0 contains $A[i]
        add $s3, $s3, $s4     # i = i + j
        bne $t0, $s5, Exit    # goto Exit if A[i] ≠ k
        j   Loop              # goto Loop
Exit:   <next instruction>
```

Note the use of pointers.

Running MIPS programs on the SPIM simulator

```
        # Example of input output
        .data
str1:   .asciiz         "Enter the number:"
        .align 2        #move to a word boundary
res:    .space 4        # reserve space to store result
        .text
        .globl main

main:   li $v0, 4               # code to print string
        la $a0, str1
        syscall
        li $v0, 5               # code to read integer
        syscall
        move $t0, $v0           # move the value to $t0
        add $t1, $t0, $t0       # multiply by 2
        sw $t1, res($0)         # store result in memory
        li $v0, 1               # code to print integer
        move $a0, $t1           # move the value to be printed into $a0
        syscall                 # print to the screen
        li $v0, 10              # code for program end
        syscall
```

SPIM simulator uses System Call for input / output operation

```
li   $v0, 5          # System call code for Read Integer
syscall              # Read the integer into $v0
```

Exercise

Add the elements of an array A[0..63]. Assume that the first element of the array is stored from address 200. Store the sum in address 800.

Read Appendix A of the textbook for a list of these system calls used by the SPIM simulator.