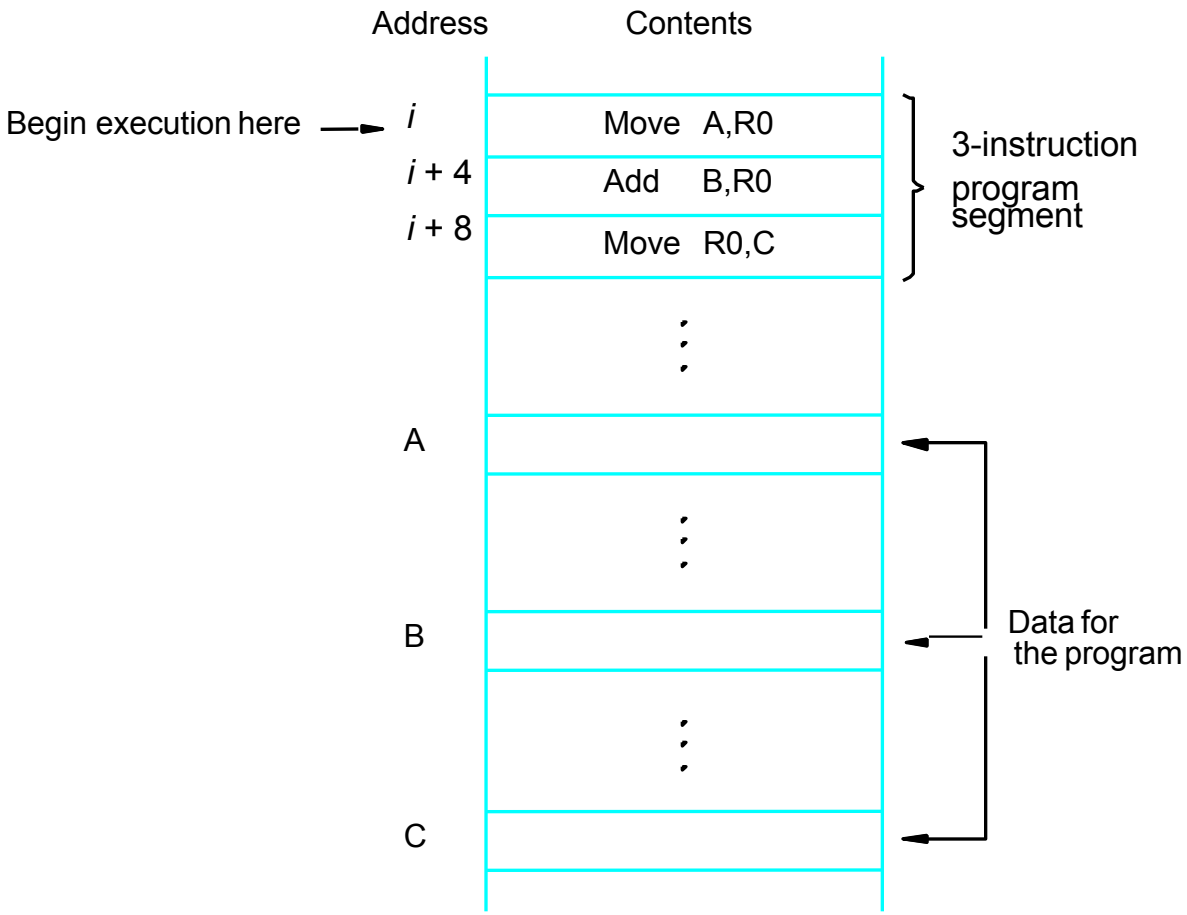
Instruction Execution: Straight-line sequencing and branching

Instruction Execution and Straight-Line Sequencing

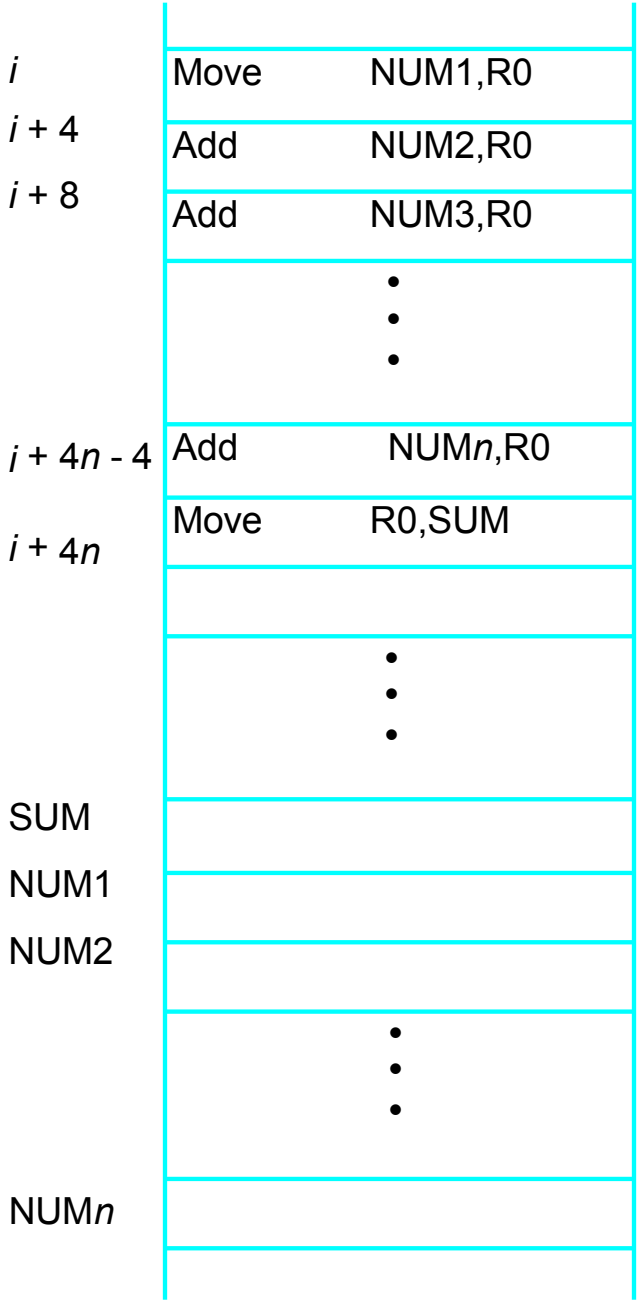


A program for [C] ← [A] + [B].

Assumptions:
- One memory operand per instruction
- 32-bit word length
- Memory is byte addressable
- Full memory address can be directly specified in a single-word instruction

Two-phase procedure
-Instruction fetch
-Instruction execute

Branching

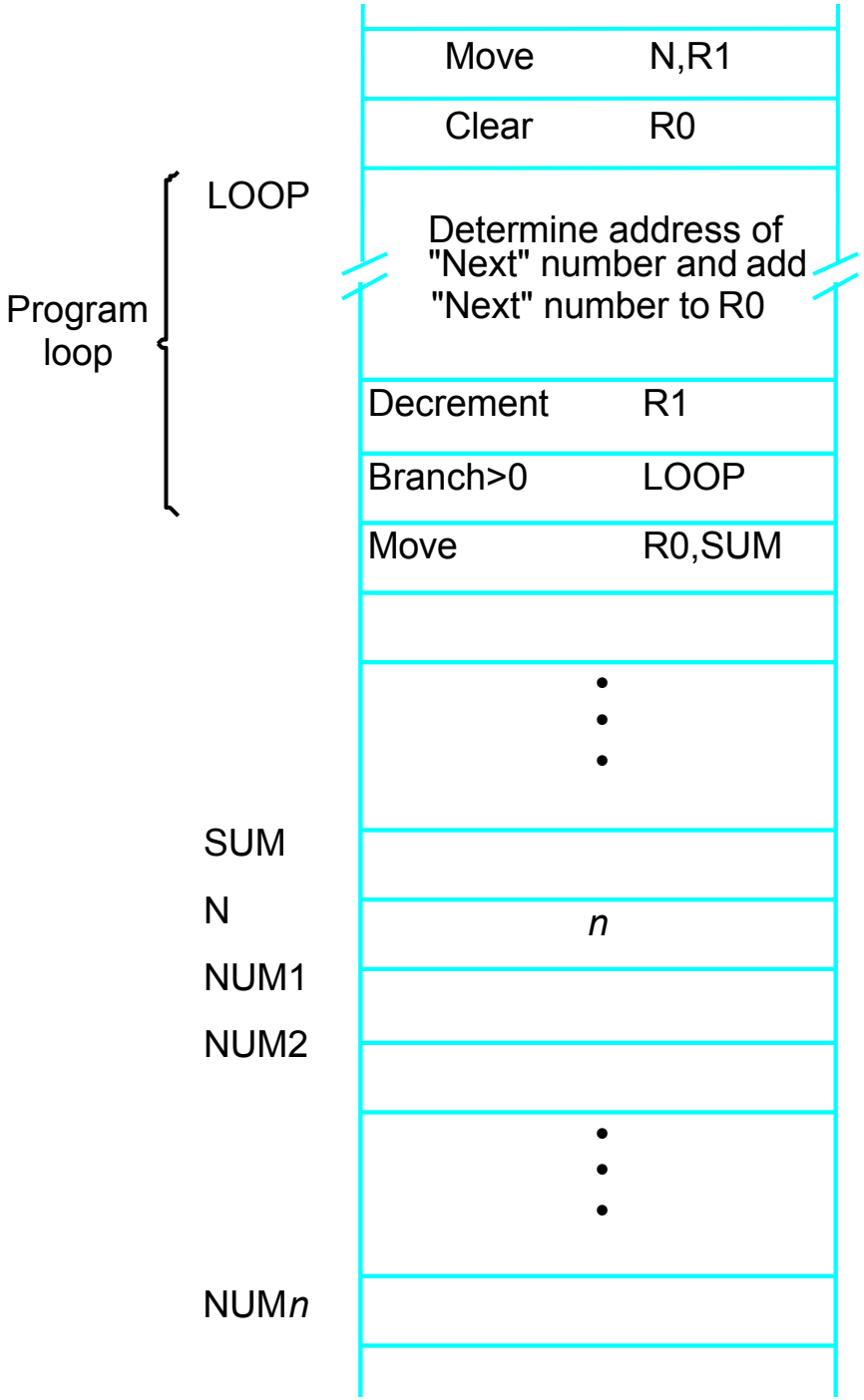


A straight-line program for adding *n* numbers.

Branching

Branch target

Conditional branch



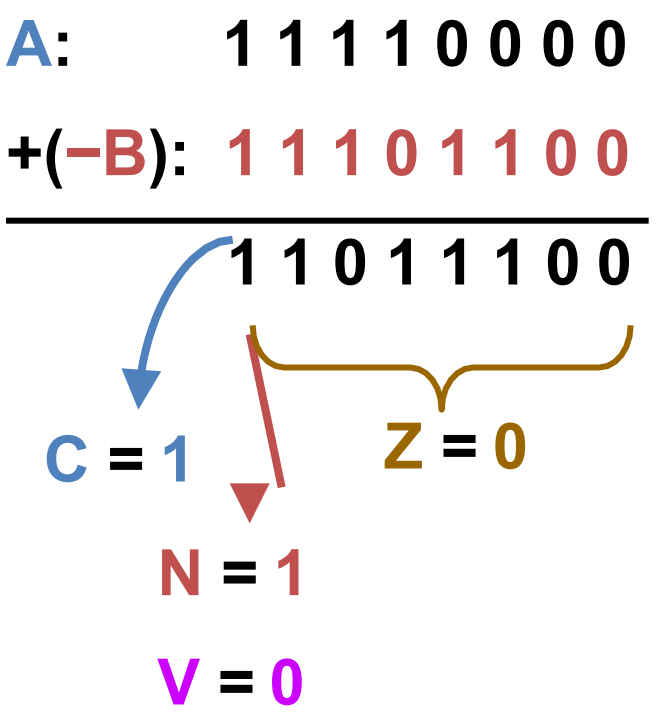
Using a loop to add *n* numbers.

Condition Codes

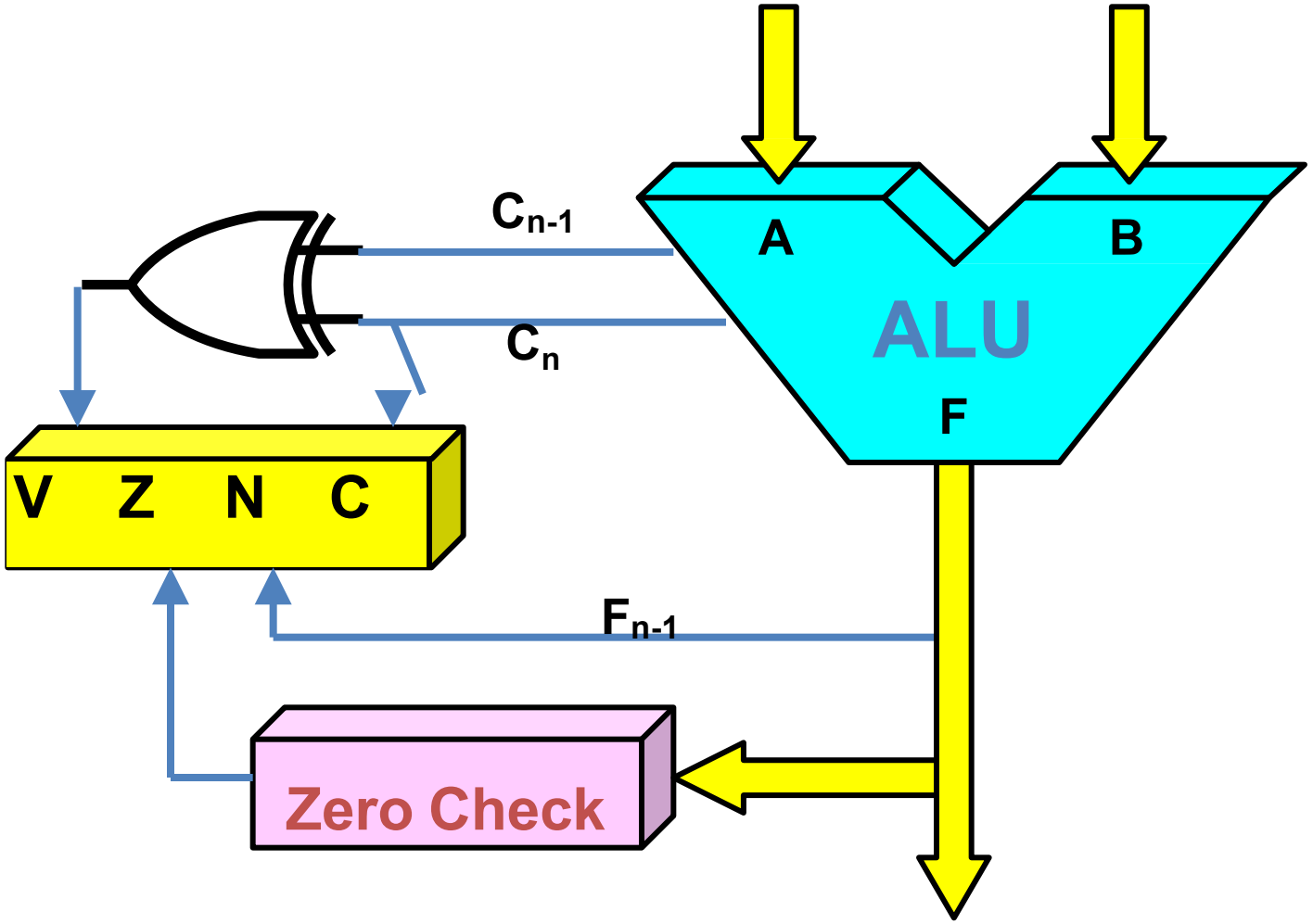
- Condition code flags
- Condition code register / status register
- N (negative)
- Z (zero)
- V (overflow)
- C (carry)
- Different instructions affect different flags

Conditional Branch Instructions

- Example:
  - A: 1 1 1 1 0 0 0 0
  - B: 0 0 0 1 0 1 0 0



Status Bits



Addressing Modes

Generating Memory Addresses

- How to specify the address of branch target?
- Can we give the memory operand address directly in a single Add instruction in the loop?
- Use a register to hold the address of NUM1; then increment by 4 on each pass through the loop.

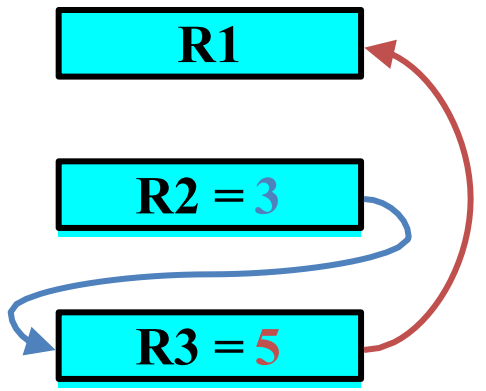
Addressing Modes

- Implied
  - AC is implied in "ADD M[AR]" in "One-Address" instr.
  - TOS is implied in "ADD" in "Zero-Address" instr.
- Immediate
  - The use of a constant in "MOV R1, 5", i.e. R1 ← 5
- Register
  - Indicate which register holds the operand

Addressing Modes

- Register Indirect
  - Indicate the register that holds the number of the register that holds the operand

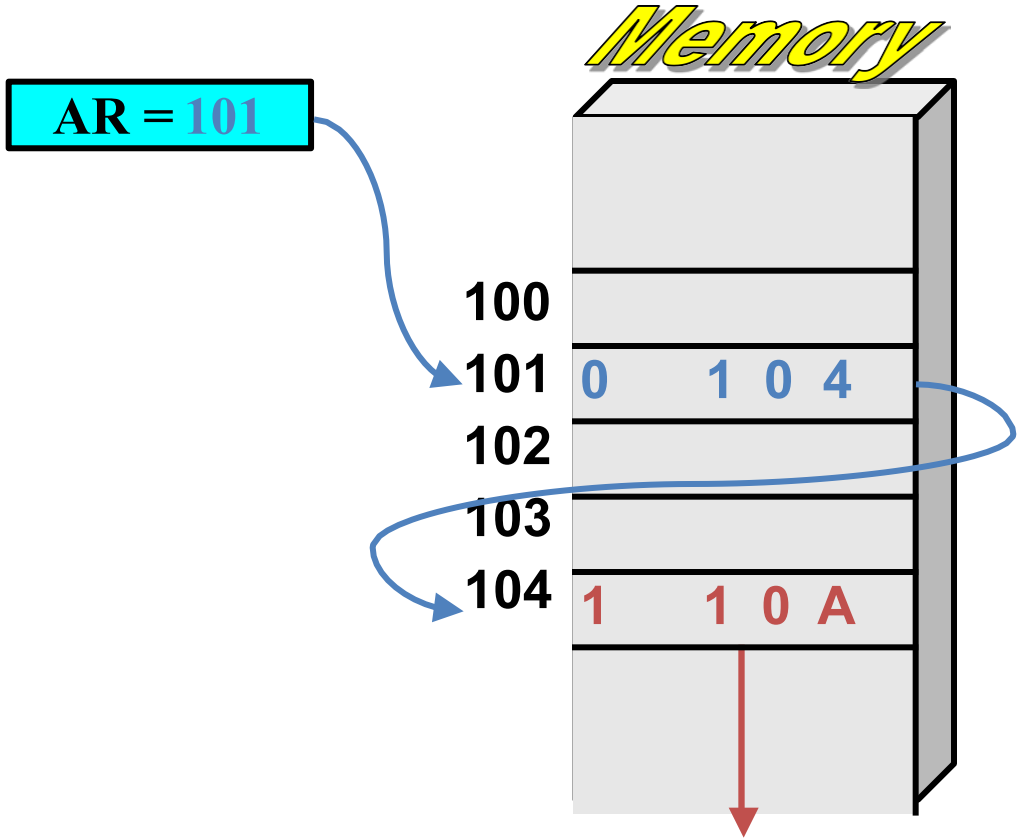
    MOV R1, (R2)



- Autoincrement / Autodecrement
  - Access & update in 1 instr.
- Direct Address
  - Use the given address to access a memory location

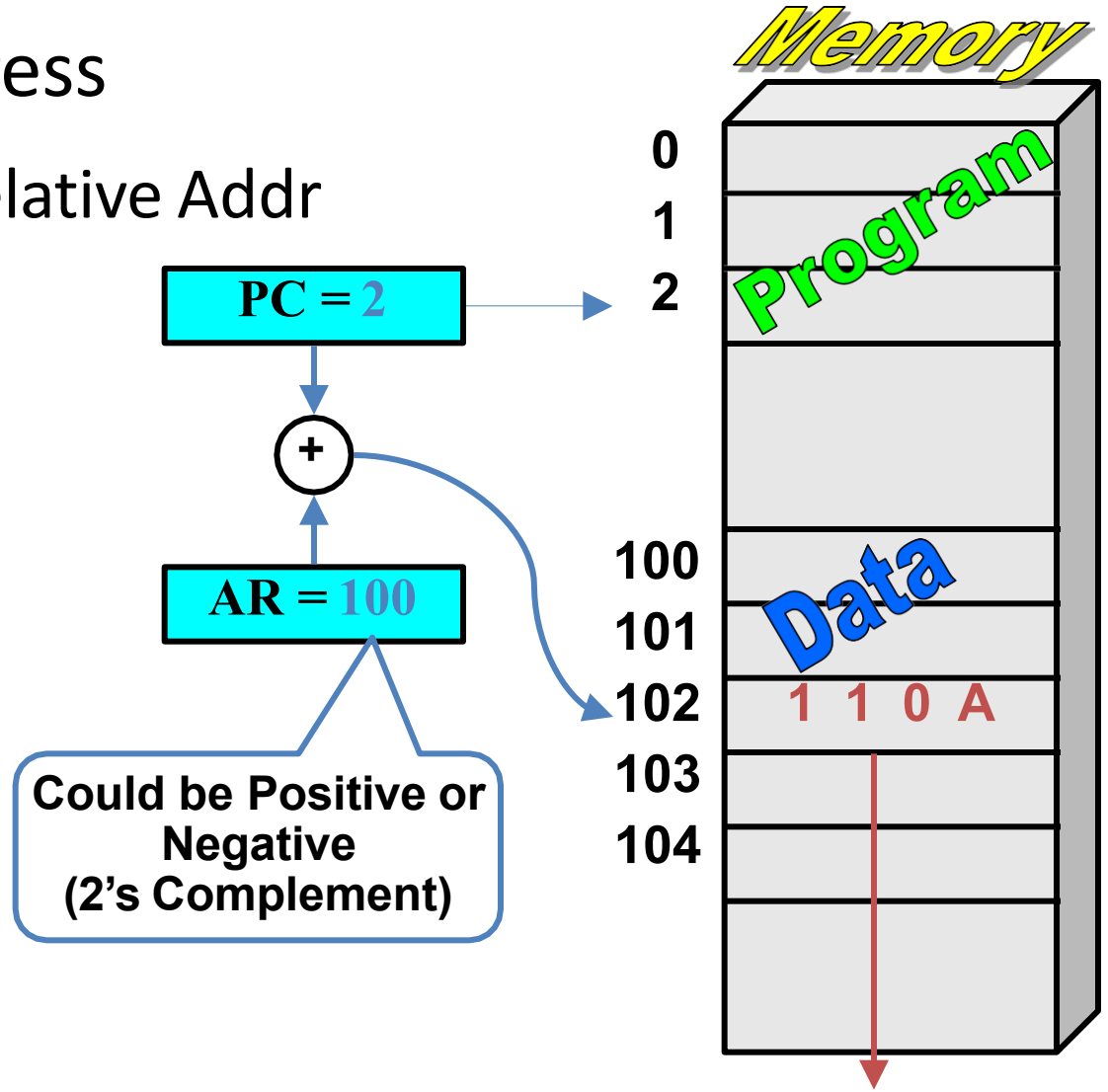
Addressing Modes

- Indirect Address
  - Indicate the memory location that holds the address of the memory location that holds the data



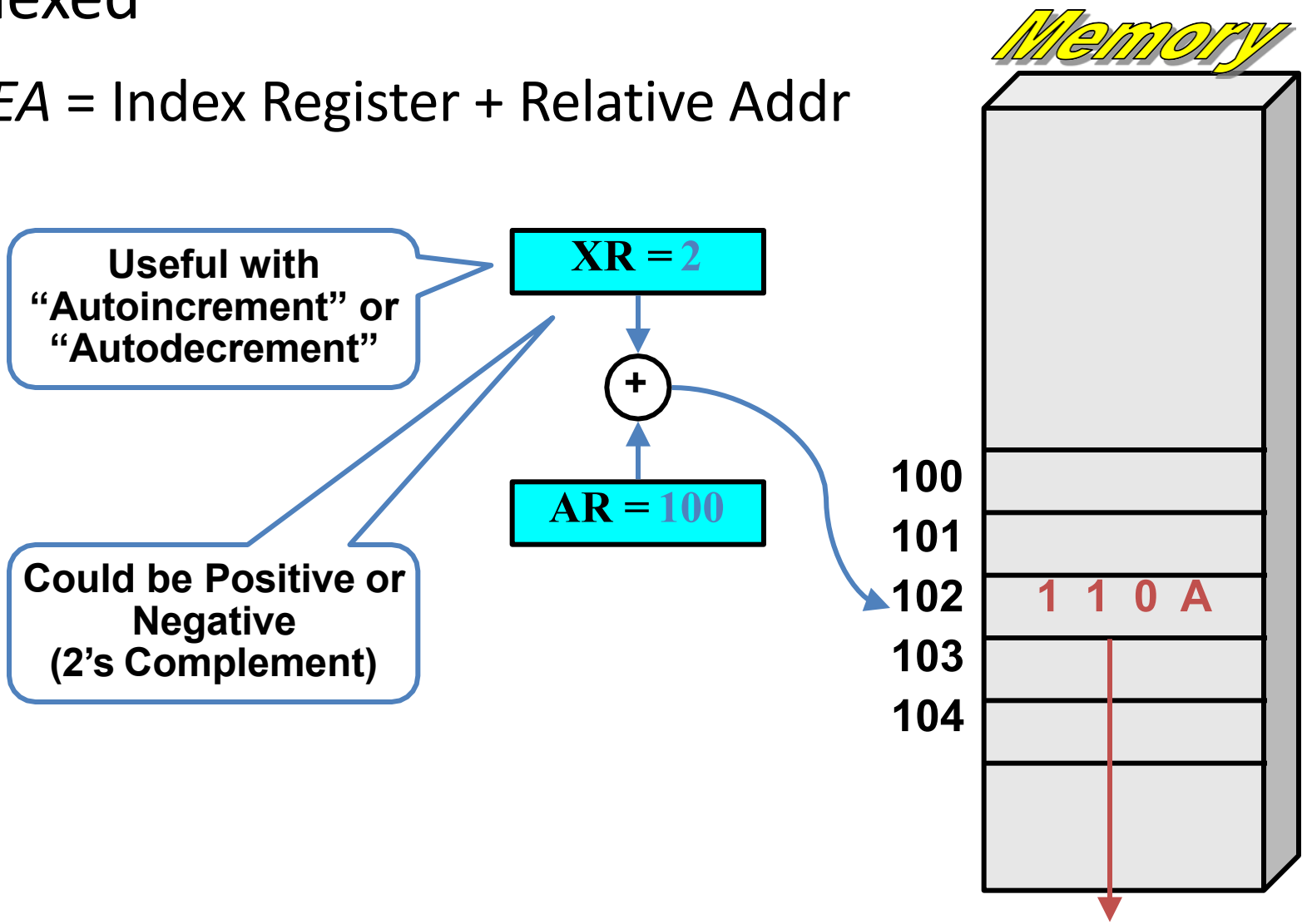
Addressing Modes

- Relative Address
  - *EA* = PC + Relative Addr



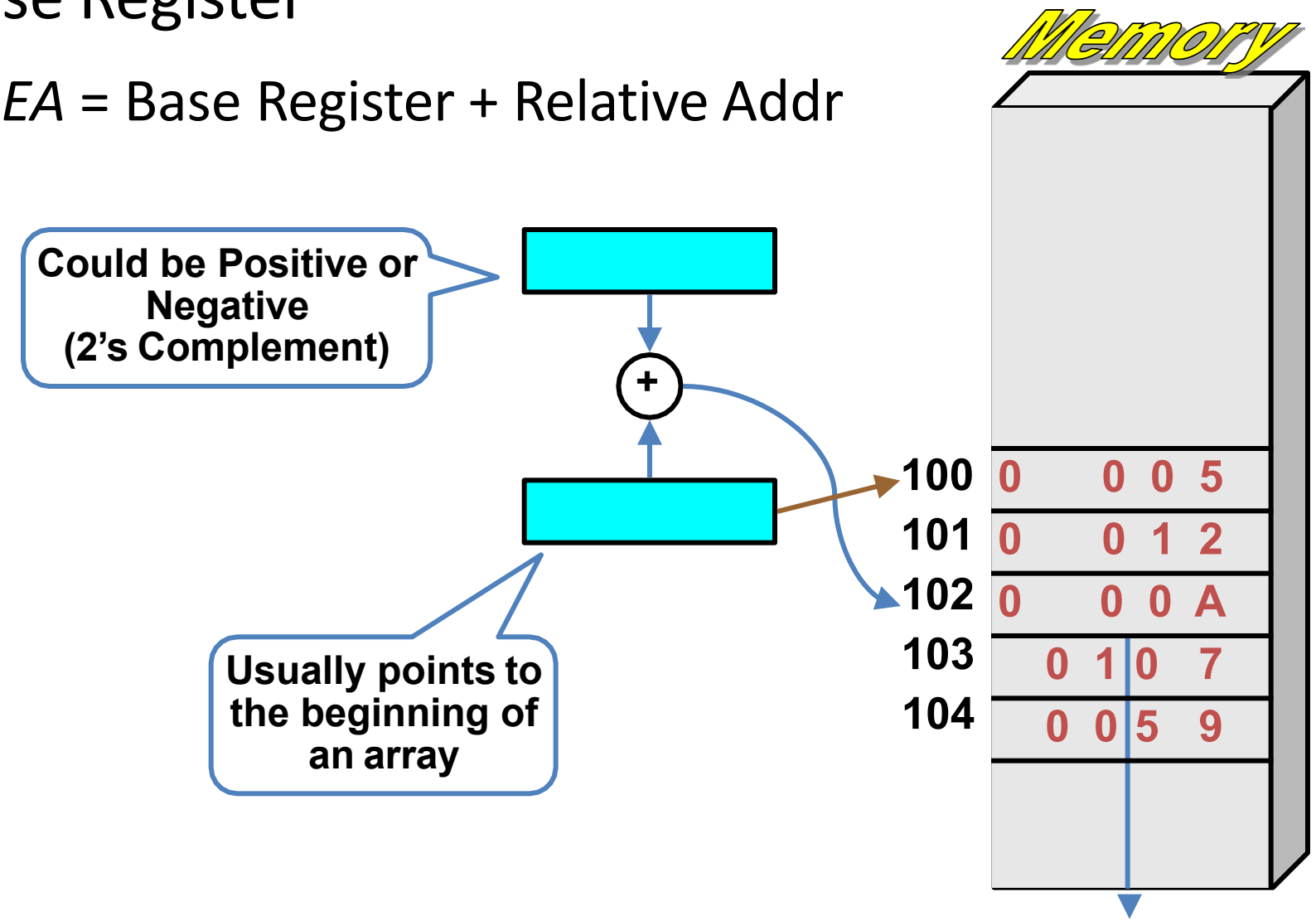
Addressing Modes

- Indexed
  - *EA* = Index Register + Relative Addr



Addressing Modes

- Base Register
  - *EA* = Base Register + Relative Addr



Addressing Modes

- The different ways in which the location of an operand is specified in an instruction are referred to as addressing modes.

Name	Assembler syntax	Addressingfunction
Immediate	#Value	Operand = Value
Register	R*i*	EA = R*i*
Absolute(Direct)	LOC	EA = LOC
Indirect	(R*i*) (LOC)	EA = [R*i*] EA = [LOC]
Index	X(R*i*)	EA = [R*i*] + X
Basewith index	(R*i* ,R*j*)	EA = [R*i*] + [R*j*]
Basewith index and offset	X(R*i*,R*j*)	EA = [R*i*] + [R*j*] + X
Relative	X(PC)	EA = [PC] + X
Autoincrement	(R*i*)+	EA = [R*i*] ; Increment R *i*
Autodecrement	−(R*i*)	Decrement R *i* ; EA = [R*i*]

Indexing and Arrays

- Index mode – the effective address of the operand is generated by adding a constant value to the contents of a register.
- Index register
- $X(R_i)$: $EA = X + [R_i]$
- The constant X may be given either as an explicit number or as a symbolic name representing a numerical value.
- If X is shorter than a word, sign-extension is needed.

Indexing and Arrays

- In general, the Index mode facilitates access to an operand whose location is defined relative to a reference point within the data structure in which the operand appears.
- Several variations:
  (R_i, R_j): $EA = [R_i] + [R_j]$
  $X(R_i, R_j)$: $EA = X + [R_i] + [R_j]$

Relative Addressing

- Relative mode – the effective address is determined by the Index mode using the program counter in place of the general-purpose register.
- X(PC) – note that X is a signed number
- Branch>0 LOOP
- This location is computed by specifying it as an offset from the current value of PC.
- Branch target may be either before or after the branch instruction, the offset is given as a singed num.