Understand address computation

Use x86 Instructions to do Transfer Data

Use x86 Instructions to do Arithmetic operations

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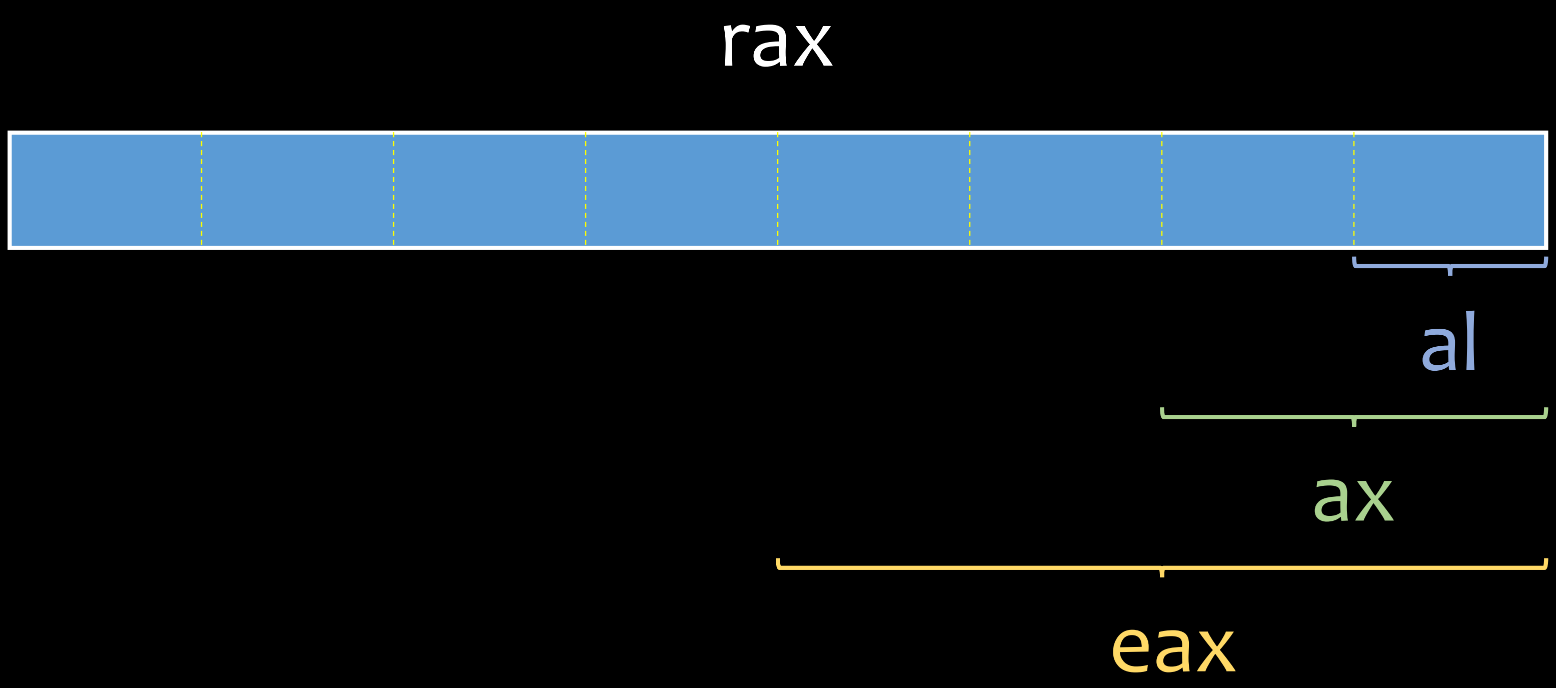
# x86 Instructions

① Transfer Data

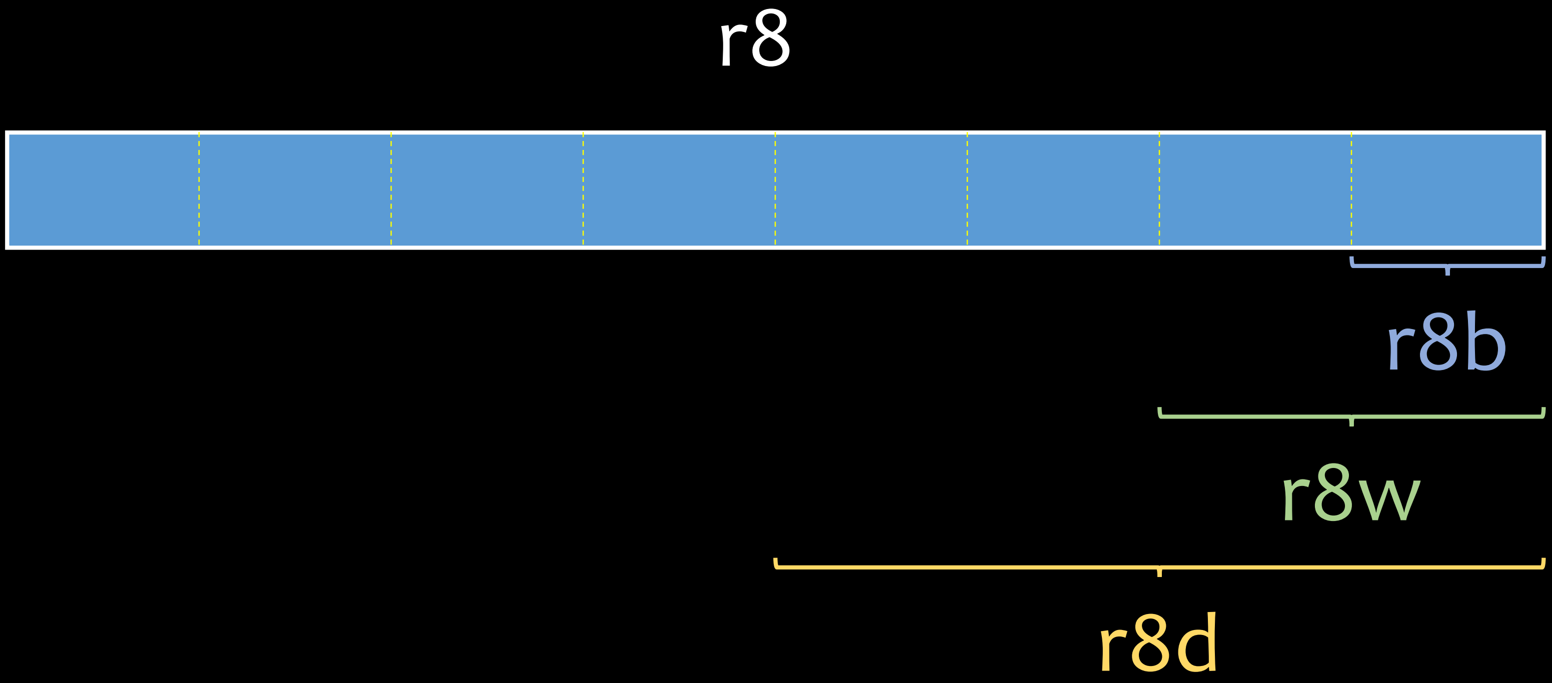
② Arithmetic Functions

# Sub-register



Same for rbx, rcx, rdx, rsi, rdi, rbp, rsp

# Sub-register



Same for r9, r10, r11, r12, r13, r14, r15

# Categories of Registers

- Data
- Address

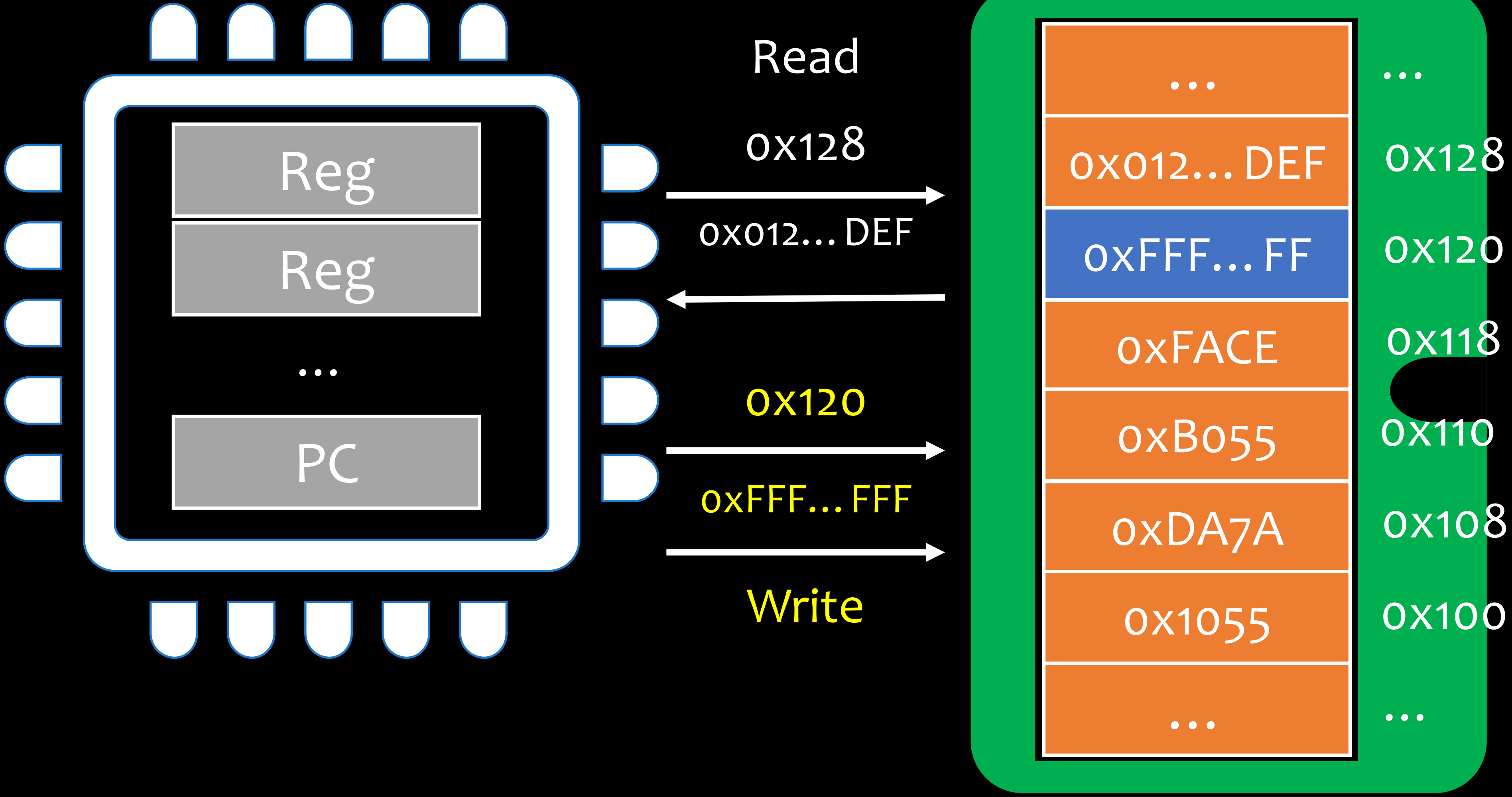
General purpose registers (GPRS)

- Floating point
- Instruction
- Conditional
- Constant (zero, one, or pi)
- Vector
- Special-purpose

# x86-64 GPRS

| | |
|---|---|
| %rax | %r8 |
| %rbx | %r9 |
| %rcx | %r10 |
| %rdx | %r11 |
| %rsi | %r12 |
| %rdi | %r13 |
| %rbp | %r14 |
| %rsp | %r15 |

# Assembly Programmer's View

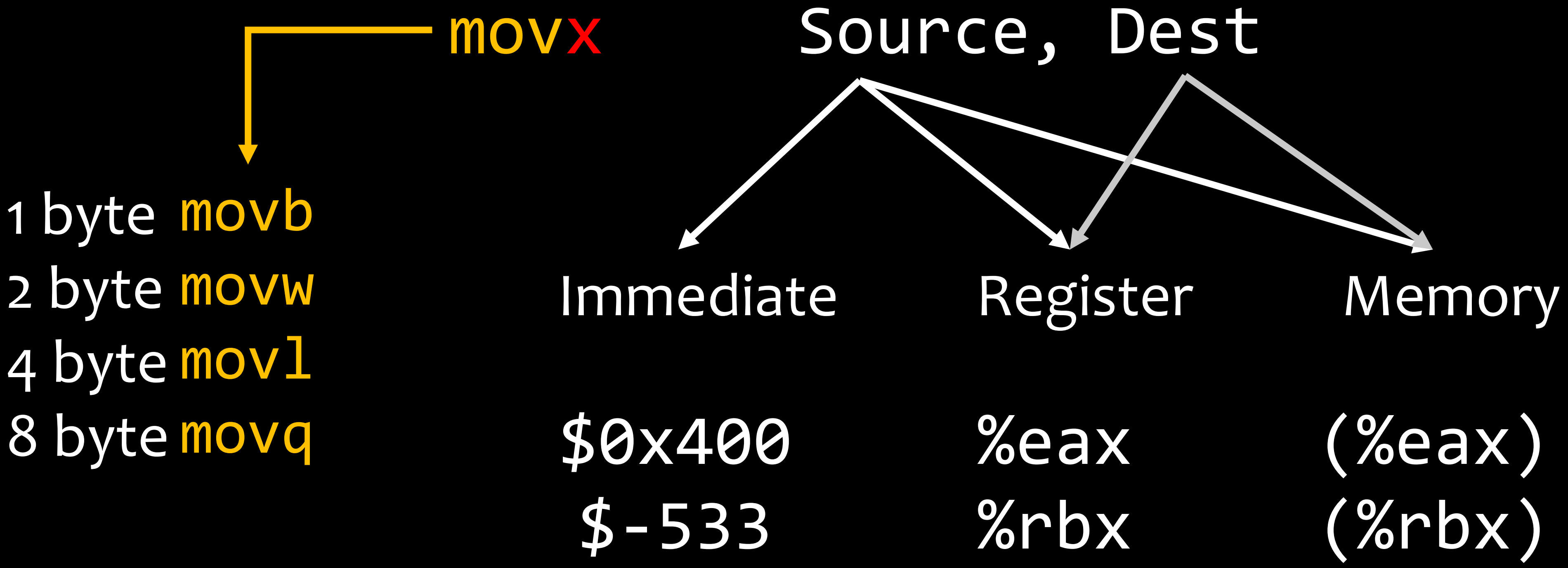


# Three Basic Kinds of Instructions

- Transfer data
  - MOV, LEA
- Arithmetic function
  - ADD, SUB, IMUL, SAL, SAR, SHR, XOR, AND, OR
  - INC, DEC, NEG, NOT
- Transfer control
  - JMP, JE, JNE, JS, JNS, JG, JGE, JL, JLE, JA, JB

# Transfer data

## MOVX



movx Source, Dest

1 byte movb
2 byte movw
4 byte movl
8 byte movq

Immediate: $0x400, $-533

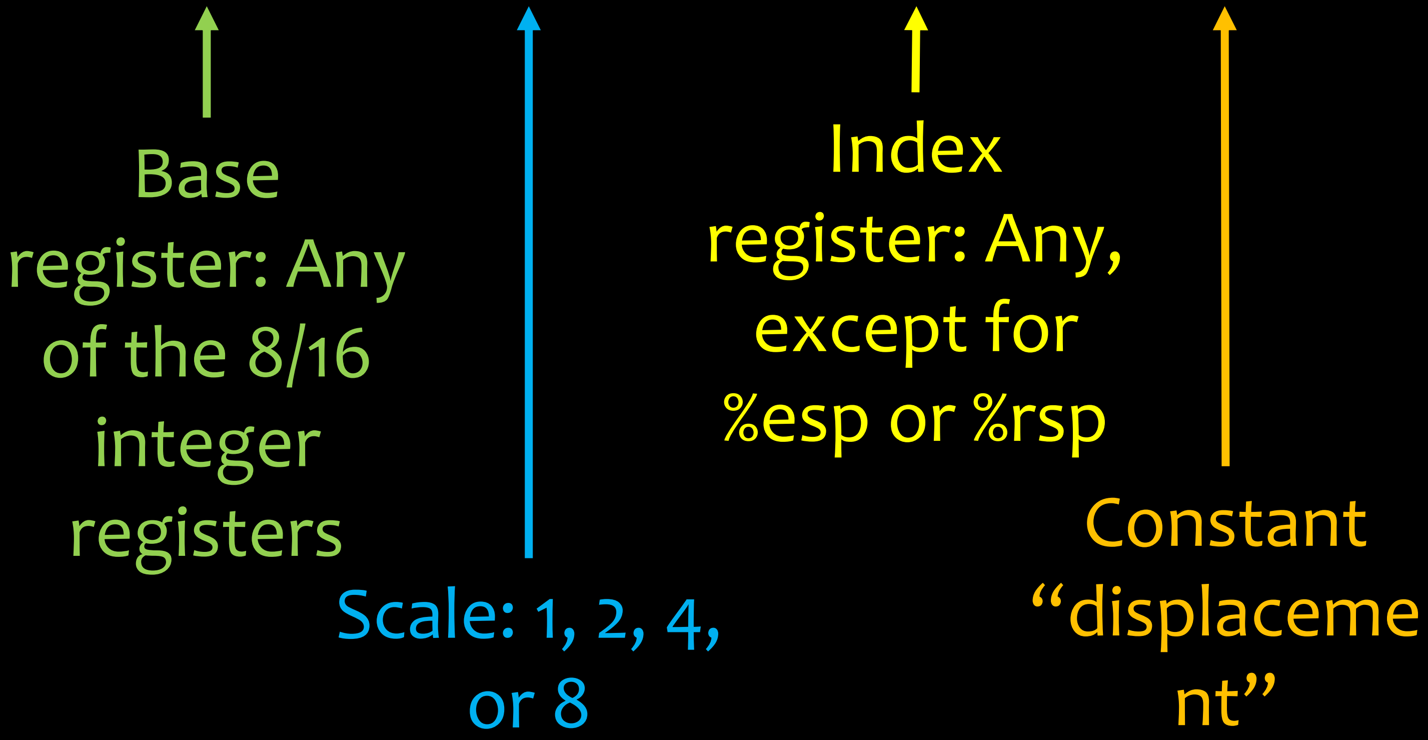
Register: %eax, %rbx

Memory: (%eax), (%rbx)

Can’t do memory-memory transfer with a single instruction.

# Memory Addressing Modes

```
D(Rb,Ri,S)
Mem[Reg[Rb] + S*Reg[Ri] + D]
```



Base register: Any of the 8/16 integer registers

Scale: 1, 2, 4, or 8

Index register: Any, except for %esp or %rsp

Constant “displacement”

# Memory Addressing Modes

| | |
|---|---|
| %edx | 0xf000 |
| %ecx | 0x100 |

| | |
|---|---|
| (Rb,Ri) | Mem[Reg[Rb]+Reg[Ri]] |
| D(,Ri,S) | Mem[S*Reg[Ri]+D] |
| (Rb,Ri,S) | Mem[Reg[Rb]+S*Reg[Ri]] |
| D(Rb) | Mem[Reg[Rb] +D] |

| **Expression** | **Address Computation** | **Address** |
|---|---|---|
| `0x8(%edx)` | `0xf000 + 0x8` | `0xf008` |
| `(%edx,%ecx)` | `0xf000 + 0x100` | `0xf100` |
| `(%edx,%ecx,4)` | `0xf000 + 4*0x100` | `0xf400` |
| `0x80(,%edx,2)` | `2*0xf000 + 0x80` | `0x1e080` |

# Swap

```
void swap_l
  (long int *xp, long int *yp)
{
  long int t0 = *xp;
  long int t1 = *yp;
  *xp = t1;
  *yp = t0;
}
```

```
swap_l:
  movq (%rdi), %rdx
  movq (%rsi), %rax
  movq %rax, (%rdi)
  movq %rdx, (%rsi)
  retq
```

x86-64

# Address Computation

LEAX load effective address

```
leax      Source, Dest
```

```
leal (%edx,%ecx,4), %eax
```

```
LEA 0x80(,%edx,2), %eax
   Compute address of value

MOV 0x80(,%edx,2), %eax
   Load value at that address
```

Suppose register %eax holds value x and %ecx holds value y. Fill in the table below:

| Instruction | Result |
|---|---|
| `leal 6(%eax), %edx` | 6+x |
| `leal (%eax,%ecx), %edx` | x+y |
| `leal (%eax,%ecx,4), %edx` | x+4y |
| `leal 7(%eax,%eax,8), %edx` | 7+9x |
| `leal 0xA(,%ecx,4), %edx` | 10+4y |
| `leal 9(%eax,%ecx,2), %edx` | 9+x+2y |

# Arithmetic Operations

| Format | Computation |
|---|---|
| add Src, Dest | Dest = Dest + Src |
| sub Src, Dest | Dest = Dest - Src |
| imul Src, Dest | Dest = Dest * Src |
| sal Src, Dest | Dest = Dest << Src |
| sar Src, Dest | Dest = Dest >> Src |
| shr Src, Dest | Dest = Dest >> Src |
| xor Src, Dest | Dest = Dest ^ Src |
| and Src, Dest | Dest = Dest & Src |
| or Src, Dest | Dest = Dest \| Src |

# Arithmetic Operations

| Format | Computation |
|---|---|
| `inc Dest` | `Dest = Dest + 1` |
| `dec Dest` | `Dest = Dest - 1` |
| `neg Dest` | `Dest = -Dest` |
| `not Dest` | `Dest = ~Dest` |

Assume the following values are stored at the indicated memory addresses and registers, fill in the table below:

| Address | Value |
|---|---|
| 0x100 | 0xFF |
| 0x104 | 0xAB |
| 0x108 | 0x13 |
| 0x10C | 0x11 |

| Register | Value |
|---|---|
| %eax | 0x100 |
| %ecx | 0x1 |
| %edx | 0x3 |

| Instruction | Destination | Value |
|---|---|---|
| `addl %ecx,(%eax)` | `0x100` | `0x100` |
| `subl %edx,4(%eax)` | `0x104` | `0xA8` |
| `imull $16,(%eax,%edx,4)` | `0x10C` | `0x110` |
| `incl 8(%eax)` | `0x108` | `0x14` |
| `decl %ecx` | `%ecx` | `0x0` |
| `subl %edx,%eax` | `%eax` | `0xFD` |

# Summary

- x86 data transfer instructions
- x86 arithmetic instructions

Kenneth Harry Olsen

Founder of Digital Equipment Corp

> “There is no reason for any individual to have a computer in his home.”