# Overview

➤ Instruction Codes

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➤ **Computer Instructions**

➤ Timing and Control

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➤ Memory Reference Instructions

➤ Input-Output and Interrupt

➤ Complete Computer Description

# Basic Computer Instructions
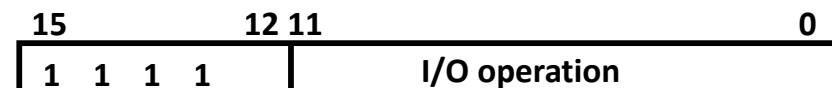
## Basic Computer Instruction Format

**1. Memory-Reference Instructions          (OP-code = 000 ~ 110)**

| 15 | 14 | 12 11 | 0 |
|---|---|---|---|
| I | Opcode | Address | |

**2. Register-Reference Instructions          (OP-code = 111, I = 0)**

| 15 | | 12 11 | 0 |
|---|---|---|---|
| 0  1  1  1 | | Register operation | |

**3. Input-Output Instructions          (OP-code =111, I = 1)**

| 15 | | 12 11 | 0 |
|---|---|---|---|
| 1  1  1  1 | | I/O operation | |

# Basic Computer Instructions

| Symbol | Hex Code I = 0 | Hex Code I = 1 | Description |
|--------|------|------|-------------|
| AND | 0xxx | 8xxx | AND memory word to AC |
| ADD | 1xxx | 9xxx | Add memory word to AC |
| LDA | 2xxx | Axxx | Load AC from memory |
| STA | 3xxx | Bxxx | Store content of AC into memory |
| BUN | 4xxx | Cxxx | Branch unconditionally |
| BSA | 5xxx | Dxxx | Branch and save return address |
| ISZ | 6xxx | Exxx | Increment and skip if zero |
| CLA | 7800 | | Clear AC |
| CLE | 7400 | | Clear E |
| CMA | 7200 | | Complement AC |
| CME | 7100 | | Complement E |
| CIR | 7080 | | Circulate right AC and E |
| CIL | 7040 | | Circulate left AC and E |
| INC | 7020 | | Increment AC |
| SPA | 7010 | | Skip next instr. if AC is positive |
| SNA | 7008 | | Skip next instr. if AC is negative |
| SZA | 7004 | | Skip next instr. if AC is zero |
| SZE | 7002 | | Skip next instr. if E is zero |
| HLT | 7001 | | Halt computer |
| INP | F800 | | Input character to AC |
| OUT | F400 | | Output character from AC |
| SKI | F200 | | Skip on input flag |
| SKO | F100 | | Skip on output flag |
| ION | F080 | | Interrupt on |
| IOF | F040 | | Interrupt off |

# Instruction Set Completeness

A computer should have a set of instructions so that the user can construct machine language programs to evaluate any function that is known to be computable.

## Instruction Types

➢ **Functional Instructions**

- **Arithmetic, logic, and shift instructions**
- ADD, CMA, INC, CIR, CIL, AND, CLA

➢**Transfer Instructions**

- **Data transfers between the main memory and the processor registers**
- LDA, STA

➢**Control Instructions**

- Program sequencing and control
- BUN, BSA, ISZ

➢**Input/output Instructions**

- Input and output
- INP, OUT