Measuring CPU performance.

→ A machine instruction consists of no of elementary micro-operations that vary in number & complexity depending on instruction & the CPU organization used.

→ A micro-operation is an elementary hardware operation that can be carried out in one clock cycle.
eg. Register transfer operations, arithmetic & logic operations etc

→ Cycles per Instruction

→ Avg. CPI of a program
program — instructions — ~~di~~ CPI

→ For a given program compiled to run on a specific machine, we can define the following parameters
- IC (Instruction count)
- CPI
- Clock cycle time (C) of the processor

→ Execution time = IC × CPI × C

$$\frac{\text{Instruction}}{\text{program}} \times \frac{\text{Cycles}}{\text{Instruction}} \times \frac{\text{Seconds}}{\text{Cycle}}$$

→ Comparisions of performance of several machines.
⇒ performance can be defined as the reciprocal of execution time

$$\text{Perf}_A = 1/XT_A \qquad \text{Perf}_B = \frac{1}{XT_B}$$

⟹ Speedup of m/c A over m/c B

$$\text{Speedup} = \frac{\text{Perf}_A}{\text{Perf}_B} = \frac{XT_B}{XT_A}$$

Q. A program is run on three different machines A, B & C. Execution time → 10, 25 & 75 are noted.
→ A is ___ times faster than B.
→ A is ___ times faster than C.
→ B is ___ times faster than C.

Q. A program running on a m/c with following parameters.
— Total no. of instructions executed = 50,000,000
— Avg CPI for the program = 2.7
— CPU clock rate = 2.0 GHz

⟹ Compute Executions time of a program.

$$\text{CPU time} = IC \times CPI \times \text{Clock cycle time}(C)$$

IC
— program used
— Compiler
— ISA

CPI
— Program used
— compiler
— ISA
— CPU orgn

Clock cycle time(C)
→ technology used to implement the CPU.

Q. Suppose we use a new compiler on the same program for which new IC = 40,000,000
new CPI = 3.0 / CPU with clock rate = 2.4 GHz
Compute the speed up.

⇒ Instruction classes
- ALU
- data transfer
- load, str

IC_i = number of instruction of type i executed

CPI_i = Cycles per Instruction for type i.

Execution Time (Total clock cycle) $= \sum_{i=1}^{n} IC_i \times CPI_i$

Instruction Count $= \sum_{i=1}^{n} IC_i$

$$CPI = \sum_{i=1}^{n} \frac{IC_i \times CPI_i}{IC}$$

$$= \sum_{i=1}^{n} \frac{IC_i}{IC} \times CPI_i$$

$$= \sum_{i=1}^{n} Freq_i \times CPI_i$$

Q. Consider an implementation of a ISA where the instruction can be classified into four types with CPI values of 1, 2, 3 & 4 respectively Two code sequences have the following instruction counts

code sequence	IC type1	IC type2	IC type3	IC type4
CS-1	20	15	5	2
CS-2	10	12	10	4

Calculate CPI for both sequences. (4)

Q. Suppose for an implementation of a RISC ISA there are four instruction types, with their frequency of occurance and CPI as shown in the table below.

Type	Freq	CPI
Load	20%	4
Store	8%	3
ALU	60%	1
Branch	12%	2