Applications of discrete mathematics:

- Formal Languages (computer languages)
- Compiler Design
- Data Structures
- Computability
- Automata Theory
- Algorithm Design
- Relational Database Theory
- Complexity Theory (counting)

Example (counting):

The Traveling Salesman Problem

Important in
- circuit design
- many other CS problems

Given:
- n cities c₁, c₂, . . . , cₙ
- distance between city i and j, dᵢⱼ

Find the shortest tour.
Assume a very fast PC:

1 flop $= 1$ nanosecond
$= 10^{-9}$ sec.
$= 1,000,000,000$ ops/sec
$= 1$ GHz.

A tour requires $n-1$ additions. How many different tours?

Choose the first city $n$ ways,
the second city $n-1$ ways,
the third city $n-2$ ways,

etc.

# tours $= n \cdot (n-1) \cdot (n-2) \cdot \ldots \cdot (2) \cdot (1) = n!$ (Combinations)

Total number of additions $= (n-1) \cdot n!$ (Rule of Product)

If $n=8$, $T(n) = 7 \cdot 8! = 282,240$ flops $< 1/3$ second.

HOWEVER . . . . . . . . . .

If $n=50$, $T(n) = 49 \cdot 50!$
$= 1.48 \cdot 10^{66}$
= 1.49 \times 10^{57} \text{ seconds}
= 2.48 \times 10^{55} \text{ minutes}
= 4.13 \times 10^{53} \text{ hours}
= 1.72 \times 10^{52} \text{ days}
= 2.46 \times 10^{51} \text{ weeks}
= 4.73 \times 10^{49} \text{ years.}

...a long time. You’ll be an old person before it’s finished.

There are some problems for which we do not know if efficient algorithms exist to solve them!