

Big picture of physics

## 6 ideas that shaped physics

- 1) Conservation Laws  $\leftrightarrow$  Symmetry  
Emmy Noether Unit C
- 2) Laws of physics are Universal  
Isaac Newton Unit N
- 3) Laws of physics are frame independent  
Albert Einstein Unit R
- 4) Electric & Magnetic Fields are unified  
James Maxwell Unit E
- 5) Particles Behave Like Waves  
Erwin Schrödinger & <sup>Werner</sup> Heisenberg Unit Q
- 6) Thermodynamics & Irreversibility  
Ludwig Boltzmann Unit T

# Goal of Physics:

To understand the physical (inanimate) world around us

What are the laws of physics?

How can we use them to predict new things?

## Laws of Physics

Obey certain Symmetry principles encapsulated by Noether's theorem

"If there exists a Symmetry in a physical theory then there will be an associated conserved quantity"



does not change in time

Symmetry

Conserved Quantity

Independent of time



Conservation of Energy

... position



" " Linear momentum

" " orientation



" " angular momentum

UNIFICATION

MECHANICS

ELECTRICITY

MAGNETISM

LIGHT

Terrestrial & Celestial

⇓  
NEWTON

↓ ↓ ↓  
MAXWELL

$v \rightarrow c$

SPECIAL RELATIVITY  
(replaces Newtonian mechanics)

$\hbar$   
QUANTUM MECHANICS  
(replaces Newtonian mechanics, contains electromagnetism)

GENERAL RELATIVITY  
(includes gravity in special relativity)

STANDARD MODEL  
QED : quantum electrodynamics  
QCD : quantum chromodynamics  
describing subatomic particles

⇓ ⇓  
STRING THEORY



# PHYSICS

REDUCTIONISM

Matter



Atom / Molecules



Protons + Electrons



Quarks



EMERGENCE



How do collections of objects (atoms, electrons) behave?

Emergence of  
Liquid

Crystals

Magnets

Superconductors



all the way to  
emergence of  
Life.