Mathematical evolution & quantum physics

Dirac Equation
$$i\hbar\frac{\partial}{\partial t}|\psi(t)\rangle = \hat{H}|\psi(t)\rangle$$

- How particles (like electrons) behave when they travel close to the speed of light.
- Combine 2 important ideas
  - Quantum Mechanics
  - Theory of Relativity
  - → Cornerstones of Modern Physics
- Predict existence of antimatter.

Euler's Identity
Mozart of Mathematics
$$e^{i\pi} + 1 = 0$$

- Link all of the constants of mathematics together.
- Basic mathematical operations
  - Simple and Profound
  - Addition
  - Multiplication
  - Exponentiation

Pi
π

- How circumference of a circle varies with its diameter.
- Irrational number, digits go on forever without repeating.
- Usage
  - GPS
  - Geometry

Einstein's Field Equation
$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu}$$

- How the Universe works at most fundamental level.
- Changed the understanding of nature and evolution of the Universe.
- Earliest moments of creation.
- Predict the existence of black holes and gravitational waves.

Bayee's Theorem
$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu}$$

- Calculate the probability that one event (A) is true, given that another event (B) is also true.
- Underlie rational thinking and decision making, rather because of any intrinsic aesthetic appeal.
- Usage
  - Detect faults
  - Surveillance
  - Military Defence
  - Search-and-rescue
  - Medical screening

Riemann's Formula
Unlock the secrets of prime numbers
$$f(x) = li(x) - \sum_{p} li(x^p) - log(2) + \int_{x}^{\infty}\frac{dt}{t(t^2-1)log(t)}$$

- Calculate the number of primes below a given number.
  - 25 Primes between 1 and 100.
- Deeper rule governing which numbers are prime.
- Primes are controlled by zeta function
- Usage
  - Message security in codes

The Euler-Lagrange Equation
$$L_x\big(t, q(t), \dot{q}(t)\big) - \frac{\mathrm{d}}{\mathrm{d}t}L_v\big(t, q(t), \dot{q}(t)\big) = 0.$$

- Describe how a rocket would go around a black hole.
  - Reveal deep links
- Express classical physics simply within a single framework.
- Deceptively short and simple
- Shape of a soap bubble

The Yang-Baxter Equation
$$(\check{R} \otimes \mathbf{1})(\mathbf{1} \otimes \check{R})(\check{R} \otimes \mathbf{1}) = (\mathbf{1} \otimes \check{R})(\check{R} \otimes \mathbf{1})(\mathbf{1} \otimes \check{R})$$

- Explain mathematical theory of knots
- Implications for Mathematics and physics
  - Waves in shallow water
  - interaction of subatomic particles
  - mathematical theory of knots
  - String theory

the Wave Equation
Start from a violin string.
$$\frac{\partial^2 u}{\partial t^2} = c^2\nabla^2 u$$

- Describe how waves behave.
  - Sound
  - Vibrations
  - Light
  - Radio Waves
- Study on phenomena
  - Earthquakes
  - Oil prospecting
  - Safety on ships

Hamilton's Quaternion Formula
$$i^2 = j^2 = k^2 = ijk = -1$$

- Works with complex numbers that include the square roots of negative numbers.
  - Quaternion algebra
  - Obscure branch of mathematics
- Usage
  - Describe objects orientations on the screen.
  - Computer graphics industry

A "Simple" Arithmetic Progression
$$6\ ,\quad 8\ ,\quad 10\ ,\quad 12\ ,\quad 14\ ,\quad 16$$

- A sequence of numbers separated by the same amout.
  - Symmetric
- Algorithmic Reduction

the Logistic Map
$$x_{n+2} = rx_n(1 - X_n)$$

- Model natural processes
  - Population
  - Animal grows and shrinks
- Example of Chaos History
- Great complexity may arise from very simple rules.