# Physics, the Hidden Magic of Our World

(A peek inside the book, for young wizards)

by A. Garrett Lisi

illustrations by GPT-5.6 Sol

Celestia

Charms

Divination

Potions

Illusion

Flows

Fire

Transfiguration

Shadows

Time Bending

Dark Arts

Healing

Summoning

Patterns

$F = ma$

$E = mc^2$

$i\hbar \frac{\partial \psi}{\partial t} = \hat{H}\psi$

$S = k \log W$

$\nabla \cdot E = \frac{\rho}{\varepsilon_0}$

# The Method

How true magic is discovered

## Guess

## Codify

## Test

## Modify

heavy falls faster

all fall the same

$d \propto t^2$

1

4

9

16

# Celestia

astronomy, planets, stars

$T^2 \propto a^3$

Ptolemy

Nicolaus Copernicus

Galileo Galilei

Johannes Kepler

ALMAGEST

# Charms

forces, gravity, electricity, magnetism, motion

$$d = \frac{1}{2} a t^2 + v t$$

$$F = ma$$

$$F = G \frac{m_1 m_2}{r^2}$$

$$\nabla \cdot E = \frac{\rho}{\varepsilon_0}$$

$$\nabla \cdot B = 0$$

$$\nabla \times E = -\frac{\partial B}{\partial t}$$

$$\nabla \times B = \mu_0 J + \mu_0 \varepsilon_0 \frac{\partial E}{\partial t}$$




Galileo Galilei

Isaac Newton




Michael Faraday

James Clerk Maxwell

PHILOSOPHIÆ NATURALIS PRINCIPIA MATHEMATICA

# Divination

## calculating the future

$T = 76\ yr$

Edmond Halley

$F = G\frac{m_1 m_2}{r^2}$

Uranus

unseen planet

Urbain Le Verrier

Neptune

Isaac Newton

PHILOSOPHIÆ NATURALIS PRINCIPIA MATHEMATIC

$v(r) \approx const$

Vera Rubin

1758

ECLIPSE PREDICTION

LOGARITHM TABLES

# Potions

## atoms, chemistry, materials

*mass in = mass out*

$2H_2 + O_2 \rightarrow 2H_2O$




$^{226}Ra \rightarrow {}^{222}Rn + \alpha$

Antoine Lavoisier

John Dalton

Dmitri Mendeleev

Marie Curie

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H | | | | | | | | | | | | | | | | | He |
| Li | Be | | | | | | | | | | | B | C | N | O | F | Ne |
| Na | Mg | | | | | | | | | | | Al | Si | P | S | Cl | Ar |
| K | Ca | ? | Ti | V | Cr | Mn | Fe | Co | Ni | Cu | Zn | ? | ? | As | Se | Br | Kr |
| Rb | Sr | Y | Zr | Nb | Mo | Tc | Ru | Rh | Pd | Ag | Cd | In | Sn | Sb | Te | I | Xe |
| Cs | Ba | La | Hf | Ta | W | Re | Os | Ir | Pt | Au | Hg | Tl | Pb | Bi | Po | At | Rn |
| Fr | Ra | Ac | Rf | Db | Sg | Bh | Hs | Mt | Ds | Rg | Cn | Nh | Fl | Mc | Lv | Ts | Og |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| La | Ce | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu |
| Ac | Th | Pa | U | Np | Pu | Am | Cm | Bk | Cf | Es | Fm | Md | No | Lr |

VINEGAR

BAKING SODA

SULFUR

CHEMISTRY
A New Science

ALCHEMY

# Illusion

## light, optics

white = red + orange + yellow + green + blue + violet

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$










$$c = \lambda f$$

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$

Ibn al-Haytham (Alhazen)

Isaac Newton

Thomas Young

James Clerk Maxwell

OPTICKS
Reflections
&
Refractions

NATURAL PHILOSOPHY of LIGHT

# Flows

## fluids, waves, sound

$$P + \frac{1}{2}\rho v^2 + \rho g h = const$$

$$F_{\text{buoyancy}} = \rho_{\text{fluid}}\, g V$$

$$\frac{\partial^2 u}{\partial t^2} = c^2 \nabla^2 u$$

$$\rho\left(\frac{\partial v}{\partial t} + v \cdot \nabla v\right) = -\nabla p + \mu \nabla^2 v + f$$

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$$

L/2

Archimedes

Daniel Bernoulli

Pythagoras

Navier & Stokes

# Fire

thermodynamics, power

$$power = \frac{work}{time}$$




$$\eta = 1 - \frac{T_{cold}}{T_{hot}}$$

$$S = k \log W$$

$$\Delta S \geqslant 0$$

$$PV = nRT$$

$T_{hot}$

$T_{cold}$

James Watt

Sadi Carnot

Ludwig Boltzmann

Rudolf Diesel







STIRLING ENGINE

# Transfiguration

## engineering, machines, vehicles



# Shadows
## quantum mechanics

$E = hf$

$\Delta x \, \Delta p \geq \frac{\hbar}{2}$

$i\hbar \frac{\partial \psi}{\partial t} = \hat{H}\psi$

$|\psi\rangle = |\text{asleep}\rangle + |\text{awake}\rangle$

$(i\gamma^\mu \partial_\mu - m)\psi = 0$

$\langle x_f | x_i \rangle = \int \mathcal{D}x \, e^{iS/\hbar}$

Max Planck

Werner Heisenberg

Erwin Schrödinger

Paul Dirac

$e^-$ $e^+$

Richard Feynman

one at a time

Quanta

Wave-Particle Duality

Probability Amplitudes

# Time Bending

relativity, space, and time

$$ds^2 = g_{\mu\nu}\,dx^\mu dx^\nu$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$E = mc^2$$

$$G_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$\theta = \frac{4GM}{c^2 b}$$

$$\Delta t' = \Delta t \sqrt{1 - \frac{2GM}{rc^2}}$$

Hendrik Lorentz

Albert Einstein

Arthur Eddington

Bernhard Riemann

TRANS-EUROPE EXPRESS

MÜNCHEN

ZÜRICH

Geometry of Curved Space

# Dark Arts

## weapons, nukes, fusion

$E = mc^2$

$x_i = \sum_j a_{ij}(x_j - x_i)$

$2\,KNO_3 + S + 3\,C \rightarrow K_2S + N_2 + 3\,CO_2$

$^{235}U + n \rightarrow {}^{141}Ba + {}^{92}Kr + 3n + energy$

$D + T \rightarrow {}^{4}He + n + 17.6\,MeV$

Chinese Alchemists

J. Robert Oppenheimer

Andrei Sakharov

Drone Wizards of Ukraine

PEACE

黑火藥

*Si vis pacem, para bellum*

# Healing

medical physics, biophysics

$e^-$ X-rays

$I = I_0 e^{-\mu x}$

A-T
G-C
A-T
G-C
A-T

A-T
G-C

Watson, Crick & Franklin

$\omega = \gamma B$

N
S

z
x
$B_0 + Gx$
MRI

$n\lambda = 2d \sin\theta$

Wilhelm Röntgen

Paul Lauterbur

PACEMAKER

Ra

# Summoning

computing, algorithms, AI

$$B_0 = 1$$

$$\sum_{k=0}^{n} \binom{n+1}{k} B_k = 0$$

$$B_1 = -\frac{1}{2},\ B_2 = \frac{1}{6},\ B_4 = -\frac{1}{30}$$

the first program, 1843

$$\delta(q, s) \to (q', s', L \text{ or } R)$$



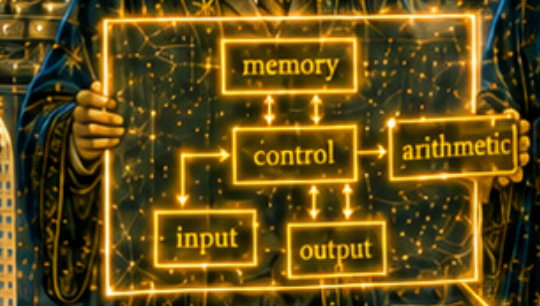


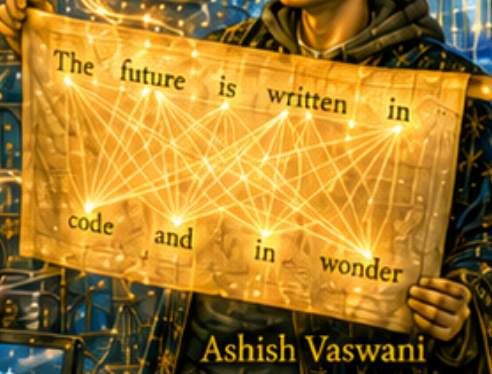


$$w_{ij} \leftarrow w_{ij} - \eta \frac{\partial L}{\partial w_{ij}}$$



$$\text{Attention}(Q, K, V) = \text{softmax}\left(\frac{QK^T}{\sqrt{d_k}}\right)V$$




Alan Turing

John von Neumann

Geoffrey Hinton

Ashish Vaswani

Ada Lovelace

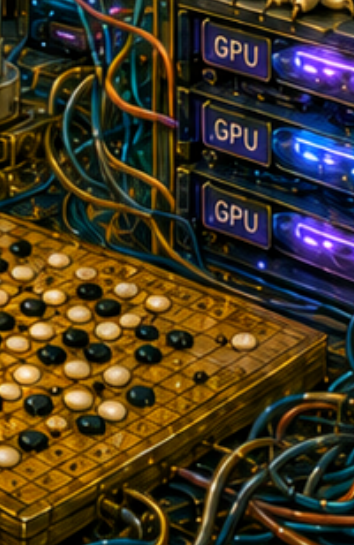












# Patterns

fundamental physics, mathematics, colliders

$$\mathcal{L} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + i\bar{\psi} \not{D} \psi + \bar{\psi}_i y_{ij} \psi_j \phi + \text{h.c.} + |D_\mu \phi|^2 - V(\phi)$$

$$C = \frac{1}{2} w + e\phi + A + w + v + \phi$$

$$j^\mu = \sum_a \frac{\partial \mathcal{L}}{\partial(\partial_\mu \phi_a)} \delta\phi_a$$

$$\partial_\mu j^\mu = 0$$

SU(3)

n p Σ⁰ Σ⁺ Σ⁻ Λ Ξ⁰ Ξ⁻ u d s

$$V(\phi) = \mu^2 \phi^\dagger \phi + \lambda (\phi^\dagger \phi)^2$$

$$\langle \phi \rangle = \frac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ v \end{pmatrix}$$

$$m_H^2 = 2\lambda v^2$$

125 GeV

Emmy Noether

Murray Gell-Mann

Peter Higgs

the Pattern Wizards of Today

$A_n$ $D_n$ $E_6$ $E_7$ $E_8$

E=mc²

I ♥ Symmetry

# The Last Page

What will you add?

*Guess · Codify · Test · Modify*

$T^2 \propto a^3$

$d = \frac{1}{2}at^2 + vt$

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$n_i \sin\theta_1 = n_2 \sin\theta_2$

$c = \lambda f$

$F = ma$

$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

$power = work/time$

$\eta = 1 - T_{cold}/T_{hot}$

$S = k \log W$

$\Delta S \geq 0$

$PV = nRT$

$F_1 d_1 = F_2 d_2$

$\sigma = F/A$

$\Delta v = v_e \ln(m_0/m_j)$

$L = \frac{1}{2}\rho v^2 S C_L$

$E = hf$

$\Delta x\, \Delta p \geq \frac{\hbar}{2}$

$i\hbar\frac{\partial\psi}{\partial t} = \hat{H}\psi$

$(i\gamma^\mu \partial_\mu - m)\psi = 0$

$\langle x_j' | x_j \rangle = \int Dx\, e^{iS/\hbar}$

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$G_{\mu\nu} = (8\pi G/c^2) T_{\mu\nu}$

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$x_i = \sum_j a_{ij}(x_j - x_1)$

$I = I_0 e^{-\mu x}$

$n\lambda = 2d \sin\theta$

$\omega = \gamma B$

$B_0 + Gx$

$Attention(Q, K, V) = softmax(QK^T/\sqrt{d_k})V$

$\delta(q, s) \rightarrow (q', s', L \text{ or } R)$

$w_{ij} \leftarrow w_{ij} - \eta \partial L/\partial w_{ij}$

$j^\mu = \sum_i \left(\partial \hat{L}/\partial(\partial_\mu \phi_i)\right)\delta\phi_i \qquad \partial_\mu j^\mu = 0$