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Beyond 1410

→ Wanted to provide a flavor for the range of physics topics that extend beyond 1410 (and may be highly relevant to your future studies in some fashion) as well as some interesting applications

NOTE: This list is by no means exhaustive, but just a sampling of the long history of human ingenuity

1) Thermodynamics

- "It's all about energy"
- microscopic vs. macroscopic → statistical mechanics
  - notion of randomness
  - what lots of random things do when considered together
  - probability, statistics
  - think about pressure and sound: what is each air molecule doing?
- Ideal Gas Law:

$$pV = nRT$$

p - pressure
V - volume
T - temperature
n - # of moles of substance
R - universal gas const. ($= 8.31\ J/mol \cdot k$)

$n = \frac{N}{N_A}$ N - # of molecules
N_A - Avogadro's # ($= 6.02 \times 10^{23}\ mol^{-1}$)

→ connection between temperature and energy

- Laws of thermodynamics
  - heat
  - entropy
  - work

→ applies to a wide range of considerations (e.g. engine, greenhouse effect)

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2) Astronomy/Astrophysics

- long history: people have looked up to the heavens for a long time
- Classic train of thought: geocentric model
  → Ptolemy and notion of epicycles (Almagest)

- Copernican revolution: heliocentric model
  → notion of a 'paradigm shift' (Thomas Kuhn)

- Astrophysics
  - what is a star? How does it function? Energy source?
  - How do planets form? How do solar systems form? Galaxies?
  - When did the universe start? When will it end? Where are its bounds? → cosmology
  - How precisely is a universe defined? Can there be more than one?

⇒ Now a whole host of new questions can emerge:
  - How many dimensions do we really exist in? Higher spatial dimensions? (e.g. hyperspace, tesseracts, unraveled 4-D cubes, Flatland, ...)
  - What is time?
  - What is the universe made up of? (e.g. matter vs. dark matter)

- Relativity: speed of light as an upper bound (but much more than just that via 'general relativity')
  → mass-energy equivalence (i.e. $E = mc^2$)

3) Quantum Mechanics

- Continuous vs. Discrete
- Large spatial scales vs. small ones (i.e. macroscopic vs. microscopic)
  → How do the rules change as one goes to smaller and smaller spatial scales (e.g. atomic dimensions)?

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- EM radiation can do 'weird' things
  → Is it a wave? A particle (i.e. photon)? [wave-particle duality]
- Fundamental unit of charge (e^-): Is there something still smaller?
  → sub-atomic particles (quarks, leptons, bosons, ...
  (collectively known as elementary particles)

- Einstein and the photoelectric effect: $E = hf$ (**photon**)
- Growth of atomic physics (e.g. Bohr model and notion of **quantized** electron orbits)
- Nuclear physics (⇝ development of nuclear energy)
- Wave functions: probability and the Heisenberg Uncertainty Principle ($\Delta x \, \Delta p_x \geq \hbar/2$)

- Schrödinger Equation:
  (1-D)

$$\frac{d^2\psi}{dx^2} = -\frac{2m}{\hbar^2}[E - U(x)]\,\psi(x)$$

m - mass of atomic particle
E - energy of particle
U - potential energy of the 'environment' the particle is in
ψ - wave function (tells you the probability is located at some region in space)

- Development of modern applications (e.g. quantum computing, lasers)

4) <u>Biophysics</u> [sales pitch for BPHS 2090, 3090, 4090 here at York]

- Duality:
  - apply concepts from physics to tackle problems in the life sciences
  - use the complexity of biological problems to explore new ideas in physics

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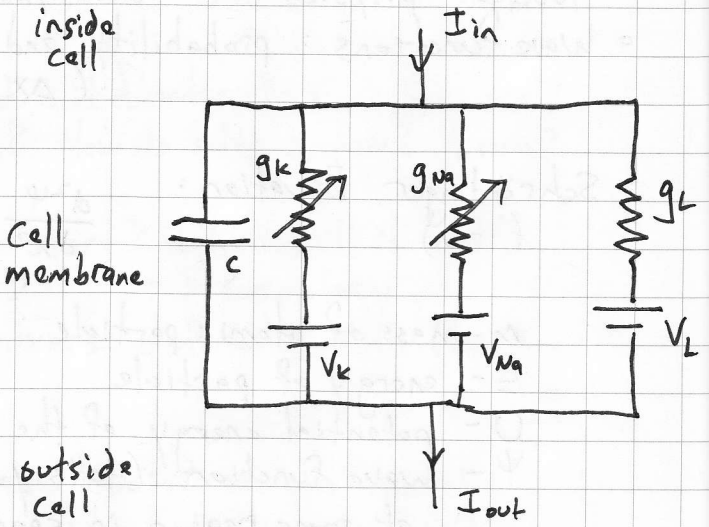
(Biophysics cont.)

- Medical physics: apply concepts in physics (e.g. EM radiation and its effects upon biological tissue) to helping patients clinically (e.g. hospitals)
  → medical physicists are crucial in clinical settings to help w/ imaging (CT, MRI) and cancer treatment (radiation

- Neurobiology
  - Hodgkin-Huxley Model
  - Neural networks
  - Imaging (e.g. fMRI, MEG)
  - cell membranes + ion channels



- Sensory transduction: How do we see/smell/touch/taste/hear the world around us?
  (transduction = converting a signal/energy from one form to another

- molecular biology and genetic manipulation (e.g. cloned mutants)

5) Many, many other areas, such as:
- optics
- mathematical physics
- complex systems (→ chaos)
- 'Standard Model', 'Theory of Everything'

keep in mind that the word physics derives from the Greek word for **NATURE** (physis)