

1. Physics 6 - Physics for Humanists

Physics 6 - Physics for Humanists
Gary R. Goldstein
Introduction



A. Einstein & D. Rothman, Summer 1939 L.I., N.Y.

5/18/2006

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2. Introduction

PHYSICS 6
PHYSICS FOR HUMANISTS
Prof. Gary Goldstein

Wave-particle Duality, Copenhagen,
Heisenberg's Uncertainty, Schrödinger's Cat,
Relativity, Space-time Continuum,
Twin Paradox, Nuclear Weapons

Modern Physics is full of ideas and concepts that are weird, counterintuitive and wondrous. These concepts arise from a framework that provides a deep understanding of our universe - both microscopic and extra-galactic. Relativity and Quantum Mechanics began at the turn of the 20th century and made possible the understanding and unraveling of the atom, the nucleus, and the fundamental constituents of all matter in the universe.

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3. Audience and Prerequisites

Audience and Prerequisites

- It is the goal of this course to make some of these profound ideas accessible to non-scientists with a minimum of mathematics.
- The prerequisite is only High School Algebra.
- Tuesday & Thursday 1:30-2:45
- Discussion sections (optional)
 - **Tues. & Thurs. 4:30-5:20**

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4. Course material

Course material

- All course material will be on online facility
- Write your name and **email address** on list in class. Are you able to use Excel?
- Syllabus available on web and handout (only once)

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5. Requirements, etc.

Requirements, etc.

- Attendance required (no more than 3 absences)
- Homework ~ every other week
- Mid-term exam + Final (multiple choice & problems)
- Ongoing small group projects
- Prof. Goldstein
- Discussion sections (optional)

Perhaps 2-3ice & 2-terms

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6. Texts

Texts

- Feynman, R.P. *Six Easy Pieces*
- Hoffmann, B. *The Strange Story of the Quantum*
- Frayn, M. *Copenhagen*
- Notes and copies of articles will be handed out or posted
- Several other texts will be on reserve
 - Gamow, *Mr. Tompkins in Paperback*
 - Lightman, *Great Ideas in Physics*
 - Hewitt, *Conceptual Physics*

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7. Science and Art

Science and Art



La Grande Jatte (1884) Georges Seurat

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8. Lecture 1: Introduction and Syllabus: Slide 8



**Nature of light
Color
Visual perception
Pixelation
Quanta & photons**

Detail, La Grande Jatte (1884)
Georges Seurat

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9. Reasons to know modern physics

Reasons to know modern physics

- Modern life is affected immeasurably
 - Practical applications - technology and society
 - Philosophical attitudes
 - 20th century history and politics - Nuclear Age
- Contemporary arts and literature
 - Copenhagen (M.Frayn)
 - Rosencrantz and Guildenstern are dead (T.Stoppard)
 - Properties of light (R.Goldstein)
 - Sci fi - e.g. Star Trek, Angels & Demons (D.Brown)
 - Visual arts (post-impressionism, surrealism, futurism, cubism, minimalism)
- Transcendence and beauty!

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10. Einstein and Bohr

Einstein and Bohr



Photograph by Paul Ehrenfest, 1930, courtesy AIP Emilio Segre Visual Archives

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11. Why should non-scientists know any physics?

Why should non-scientists know any physics?

- 2 Physics Revolutions in 20th Century
 - Relativity - removed humankind further from the absolute
 - Quantum Mechanics - replaced certainty with probability
- Applications
 - The **Nuclear** Age! - weapons, proliferation, power plants (political, historical implications, e.g. Iraq, Niger & yellowcake; Iran & Uranium processing)
 - Lasers - surgery, surveying, bar codes, holograms, hi-tech weaponry
 - Micro-electronics- computers, surveillance, **Information Age!**

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12. Syllabus

Syllabus

- Estimations - Fermi problems (see notes)
 - Piano tuners, hairs, oil consumption, sand
 - Importance of scale or order of magnitude
- Space, Time → Relativity (Lightman & notes)
 - Coordinates and clocks, Frames of reference
 - Primacy of light, Maxwell's EM waves, medium
 - Relativity of time, contracted meter sticks
 - Twin paradox, event descriptions, symmetry
 - Momentum & energy, $E=mc^2$, nuclear energy
 - Equivalence principle & gravity

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Syllabus-2

Syllabus-2

- **Probability (class notes)**
 - Randomness - coin tossing
 - Deterministic systems with probabilistic outcomes
- **Quantum mechanics (Hoffmann & Feynman)**
 - Heisenberg's Uncertainty Principle - non-deterministic
 - Transitions & decays - random & non-deterministic
 - Virtuality - barrier penetration & busy vacuum
 - Entanglement - Schrödinger's cat
 - Copenhagen - interpretation & play (Frayn)

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Syllabus-3

Syllabus-3

- **Nuclear Energy (notes & handouts)**
 - Nuclear Structure, Energy, Kinematics
 - Genesis 1940: The Frisch-Peierls Memorandum
 - Assembling the Bomb
 - Radiation Effects, **Blast & Burn**
 - How to Build a Hydrogen Bomb!
 - Delivery systems
 - Proliferation
 - Nuclear Power

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15.

Quantities and Units

Quantities and units

Physics is a quantitative science & so any appreciation of its contribution to the modern world view obliges us to do some mathematics.

Some arithmetic, algebra, geometry, "scientific notation". (Don't panic, you'll be surprised at how little is necessary.)

But physics is not just mathematics. Involves real phenomena - nature - requires specification of measurable quantities. Of fundamental importance are units of those quantities.

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16.

Estimations

Estimations

We begin with some estimations that, to the uninitiated, seem totally impossible to accomplish with any confidence. You'll be surprised! These estimates are called "Fermi problems".

Let's begin with the question "how many piano tuners are there in the Boston area?"

Where to begin?

Check the website for Notes on Estimation

Scale and order of magnitude are very important

- For orders of magnitude see website:
<http://microcosm.web.cern.ch/microcosm/P10/english/>

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