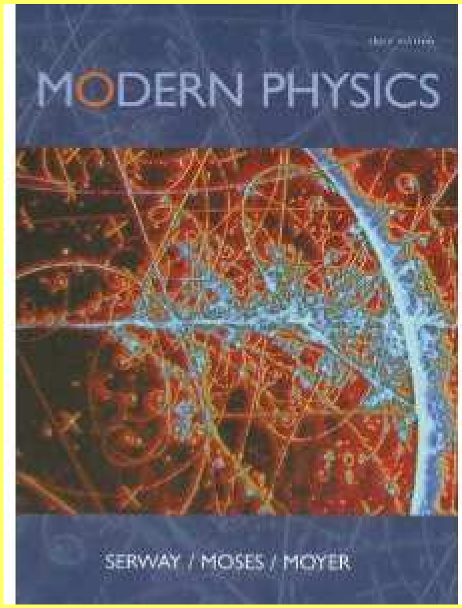
Welcome to PHYS 201
Modern Physics
Fall 2018

Lectures: MWF 10:00-10:50 am
Fridays 2:00-2:50 pm

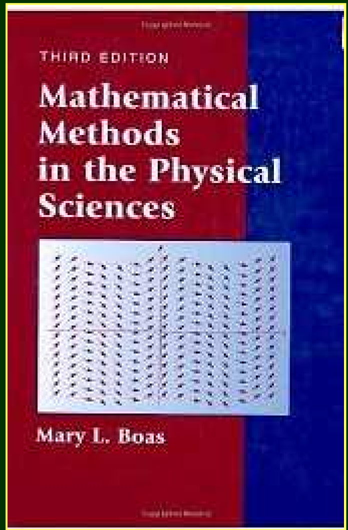
Co-requisite PHYS 251
Experimental Atomic Physics

Textbook

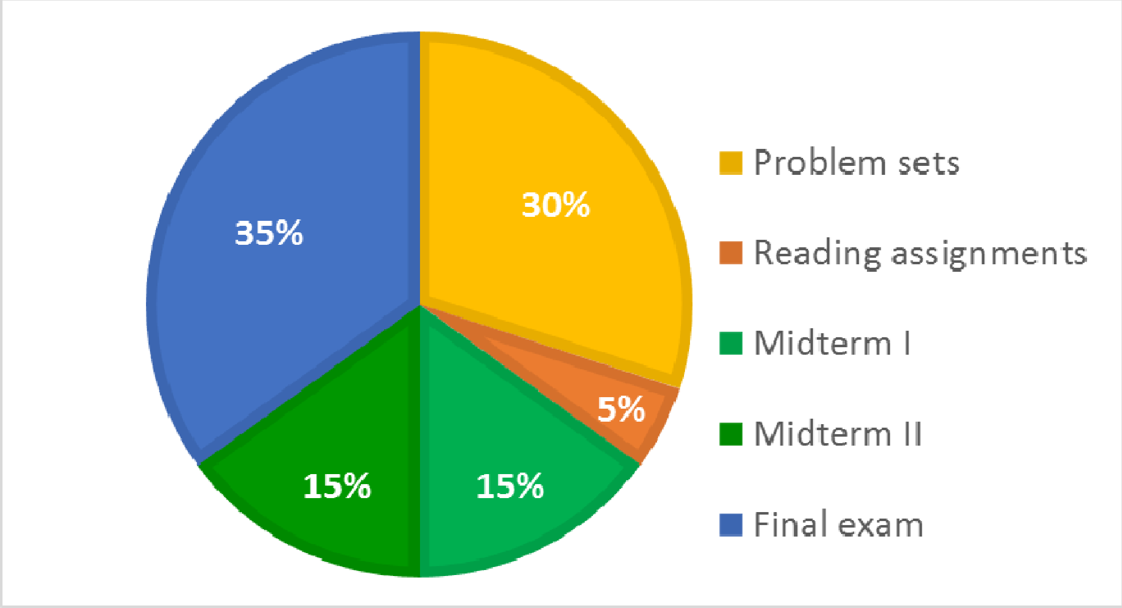


Required text:
Modern Physics by R. A. Serway, C. J. Moses, C. A. Moyer,

Possibly useful math resource:
M. L. Boas, *Mathematical Methods in the Physical Sciences*, 3rd Ed.



Grading



Default grade assignment

A	94	B-	80
A-	90	C+	77
B+	87	C	74
B	84	C-	70

There will be extra credit opportunities!

This assignment <u>may be adjusted</u> for the test scores.

Homework

http://www.physics.wm.edu/~inovikova/phys201/CourseSchedule.htm

Physics 201: Modern Physics

Fall 2018 Course schedule

Week	Material covered	Homework assignment	Reading assignment
8/29-8/301 (short week)	Introduction, Relativity (SMM, Chapter 1)	No homework	No assignment
9/03-9/07	Relativity I (SMM, Chapter 1)	Homework #1 Due 9/07	The Michelson-Morley Experiment(s) Due 9/10
9/10-9/14	Relativity I (SMM, Chapter 1),	Homework #2 Due 9/14	Time travel Due 9/17
9/17-9/21	Relativistic dynamics, nuclear reactions, elementary particles (SMM, Chapters 2, 13, 15)	Homework #3 Due 9/21	Einstein as a Celebrity Due 9/24
9/24-9/28	Emergence of quantum (SMM, Chapter 3) *Midterm test #1 (9/28)*	No homework	No assignment
10/01-10/05	Quantum theory of light (SMM, Chapter 3)	Homework #4 Due 10/05	

Problem sets: 11 assignments (turned in on paper), due beginning of the corresponding **Friday** class. Late assignments will be accepted with a 50% penalty when submitted on or before **Monday** class following the due date. Any assignment turned in after that time **will not be accepted** (unless you **obtained a permission** form me beforehand).

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Reading assignments: (roughly) weekly reading assignments regarding the historical significance of the events discussed in class. After each discussion, you should write about ½ page of thoughts, comments, and questions about the material (submitted in Blackboard).

My contact information

Office: Small 251
E-mail: ixnovi@wm.edu or inovikova@physics.wm.edu
Office hours: W 11am – 1pm or by appointment
Telephone: (757) 221-3693
Web-site:
http://www.physics.wm.edu/~inovikova/phys201.html or in Blackboard

***Area of research**: experimental atomic physics and quantum optics*
***Research projects**: quantum memory and slow light, miniature atomic clocks, "squeezed" light, optical microresonators, optical properties of thin films, etc.*
***Lab location:** Small 65, 34 (basement)*
***Web-site**: http://physics.wm.edu/~inovikova/group.html*

Necessary background

Prerequisites: This course assumes a solid background in first year physics and math.

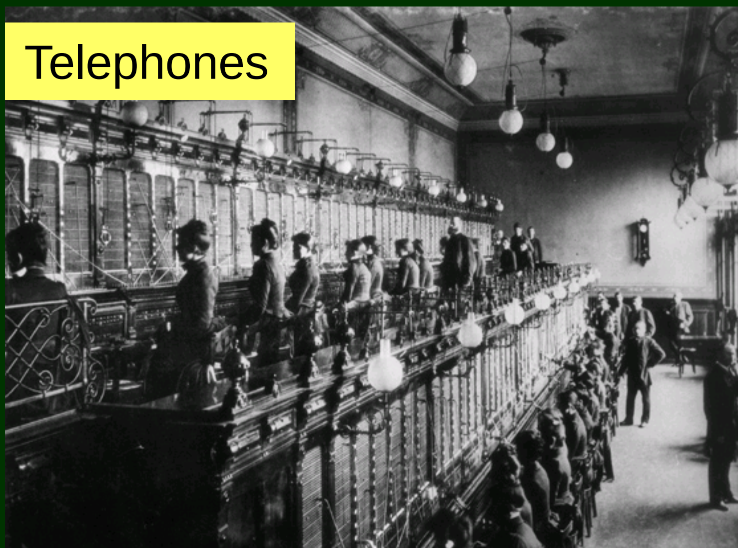
- Full year of calculus-based general physics PHYS 101-102.
- Algebra-based general physics courses PHYS 107-108 are often not sufficient.
- AP Physics is usually not sufficient.
- Full year of calculus at the level of Math 111-112 (and here AP credit is sufficient).

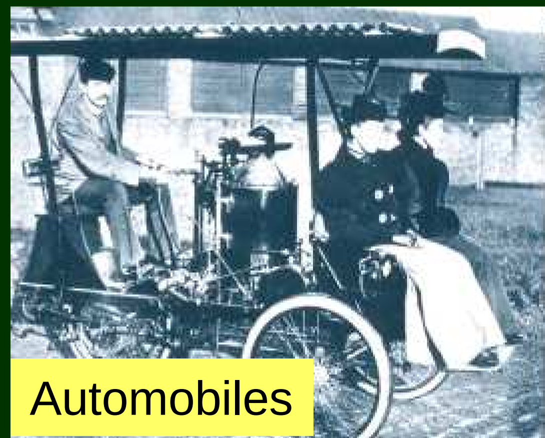
This is a fast-paced and challenging course.
Judge your preparedness before you dive in!

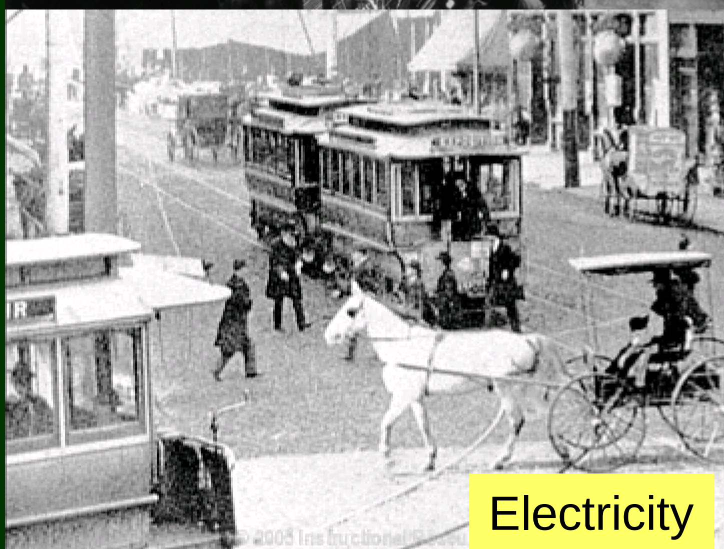
Modern physics: Road Map

Where things gets curiouser and curiouser…

Birth year of modern physics - 1895


Telephones


Automobiles


Electricity


Industry (steam engine-driven)

“Classical” physics – XIX century

- √ Mechanics
- √ Electromagnetism
- √ Thermodynamics
- √ Optics

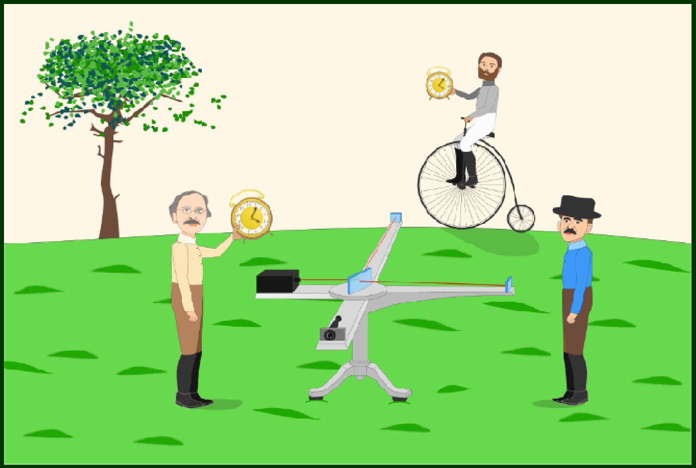
Physics at the end of the XIX century approached its ultimate goal: to produce a clear deterministic description of the world (as observed by humans).

Axioms of the "classical" physics

All the properties of any objects can be determined with arbitrary precision

Time is a universal property

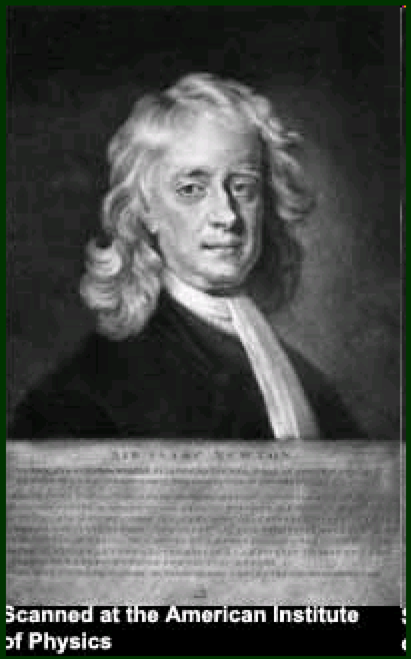
Any property of an object at any moment of time can be calculated from the object's properties at one moment of time



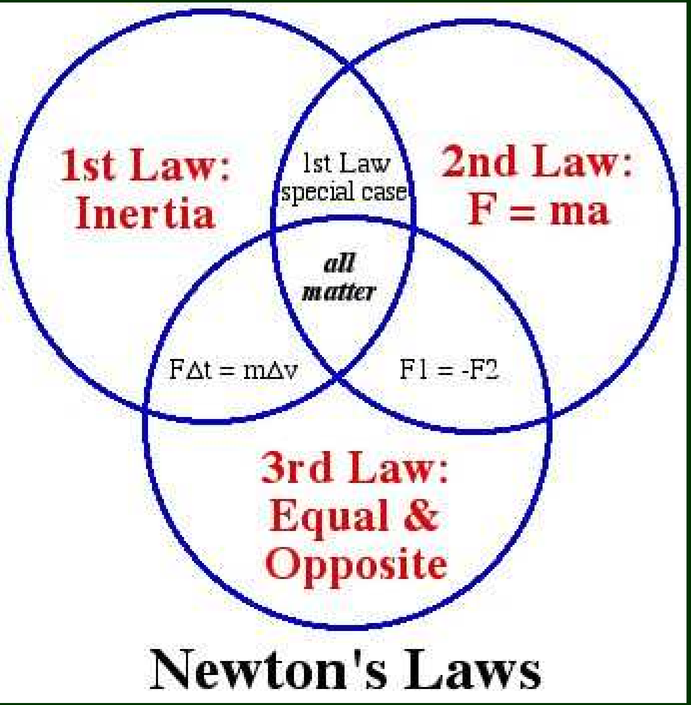
The act of the measurement does not change the state of the object

All matter can be described as a collection of particles. Collective motion of such particles can be described as a wave, a delocalized oscillation of a matter.

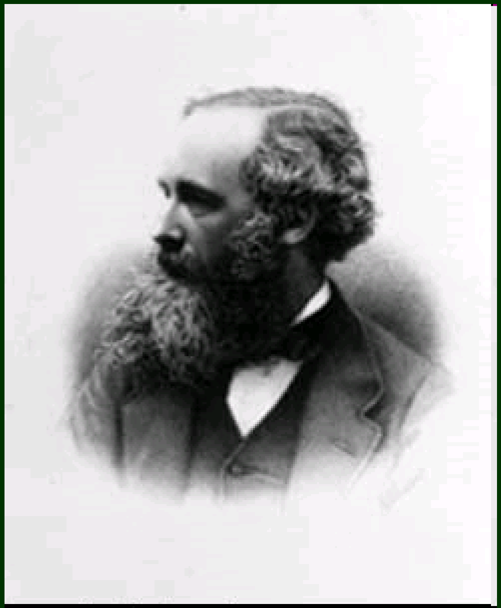
“Classical” physics: Mechanics



If one knows the position of an object, and all forces acting on it, one can use Newton’s laws of motion to predict with certainty, where the object will be in the future (or where it was in the past).



"Classical" physics: Electromagnetism



$$\vec{\nabla}\cdot\vec{E}=0 \qquad \vec{\nabla}\times\vec{E}=-\frac{\partial\vec{B}}{\partial t}$$

$$\vec{\nabla}\cdot\vec{B}=0 \qquad \vec{\nabla}\times\vec{B}=\frac{1}{c^2}\frac{\partial\vec{E}}{\partial t}$$

$$\oint \mathbf{E}\cdot d\mathbf{A} = \frac{q_{enc}}{\varepsilon_0}$$ **Gauss's law (electricity)**

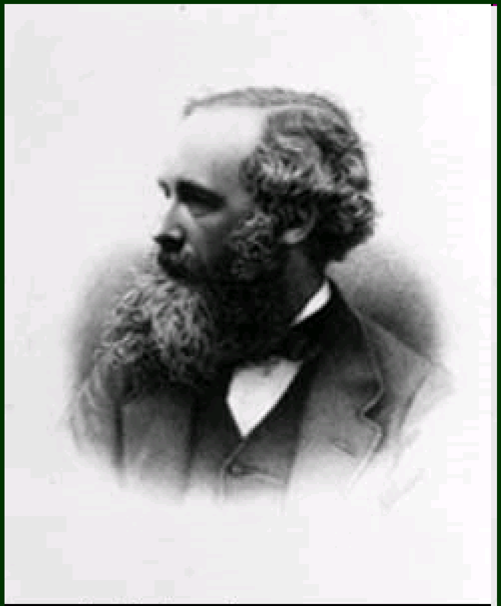
$$\oint \mathbf{B}\cdot d\mathbf{A} = 0$$ **Gauss's law (magnetism)**

$$\oint \mathbf{E}\cdot d\mathbf{s} = -\frac{d\Phi_B}{dt}$$ **Faraday's law**

$$\oint \mathbf{B}\cdot d\mathbf{s} = \mu_0\varepsilon_0\frac{d\Phi_E}{dt} + \mu_0 i_{enc}$$ **Ampere's law**

If one knows the positions and velocities of any electrical charges of an object, one can use Maxwell's equations to describe electrical and magnetic forces acting on them.

“Classical” physics: Electromagnetism



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$$\oint \mathbf{E} \cdot d\mathbf{A} = \frac{q_{enc}}{\varepsilon_0}$$ **Gauss’s law (electricity)**

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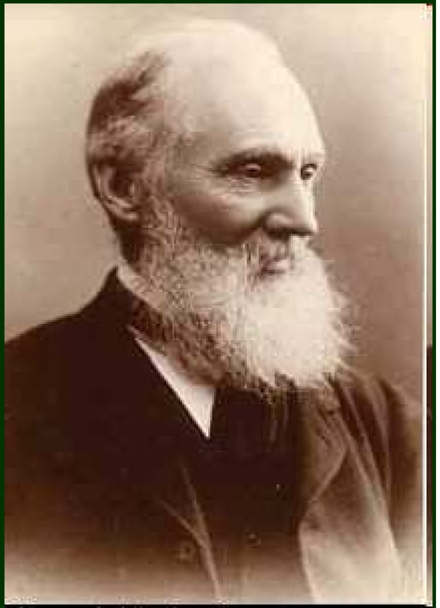
If one knows the positions and velocities of any electrical charges of an object, one can use Maxwell’s equations to describe electrical and magnetic forces acting on them.

And even explain the nature of light and derive all laws of optics!
(well, almost…)

"Classical" physics: Thermodynamics



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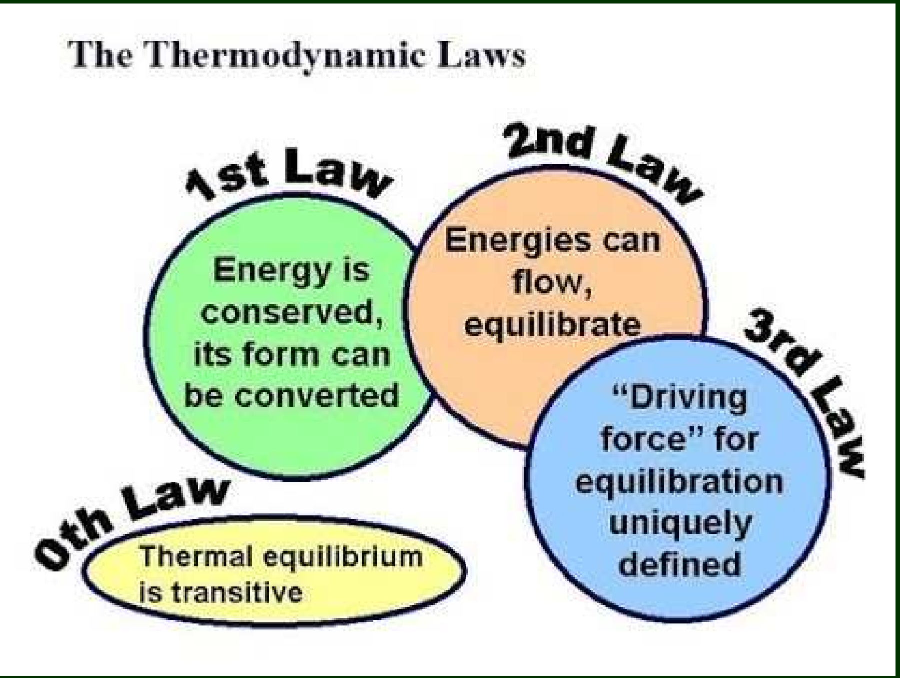
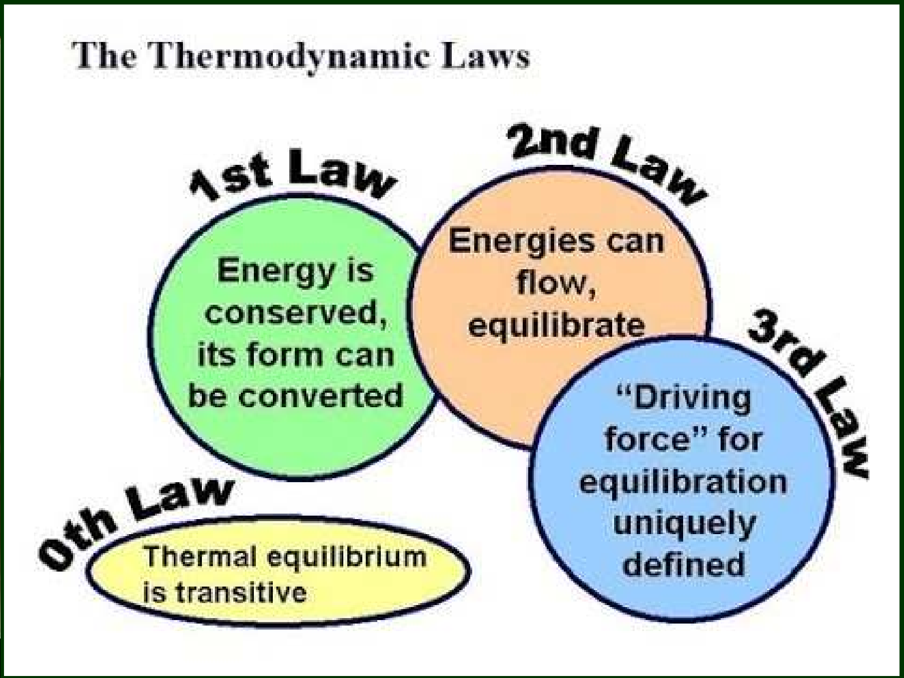
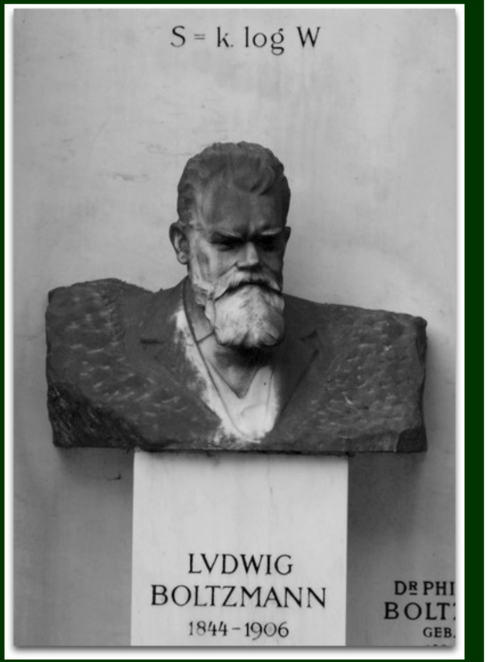


“Classical” physics: Thermodynamics





Statistical treatment is introduced for the first time! The behavior of a complex system can be predicted accurately without detailed knowledge of individual behavior of each component.

Status of physics

There is nothing new to be discovered in physics now. All that remains is more and more precise measurements.

The more important fundamental laws and facts of physical science have all been discovered that the possibility of their ever being supplanted in consequence of new discoveries is exceedingly remote… Our future discoveries must be looked for in the sixths place of decimals.

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Lord Kelvin, 1900

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A. A. Michelson, 1900

Birth of “modern” physics

Scanned at the American Institute of Physics

In a speech to the Royal Institution in 1900, Lord Kelvin himself described two “**dark clouds on the horizon**” of physics:

The question of the existence of an electro-magnetic medium—referred to as “ether” or “aether.”

➡ **Special relativity**

The failure of classical physics to explain blackbody radiation.

➡ **Quantum mechanics**

Birth of modern physics (cont)

- Discovery of the X-rays (Roentgen, 1895)
- Discovery of Radioactivity (Becquerel, 1896)

➡ **Nuclear physics**

- Discovery of the electron (Thomson, 1896)
- Discovery of the Zeeman effect - splitting of atomic spectral lines in magnetic field (Zeeman, 1897)

➡ **Quantum mechanics, atomic physics**

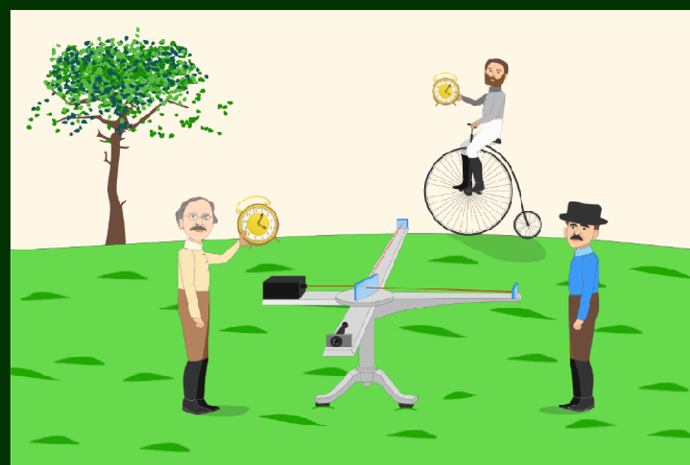
Axioms of the "Classical" physics

All the properties of any objects can be determined with arbitrary precision

The act of the measurement does not change the state of the object

Tim[illegible] univ[illegible]al property

Special relativity



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Quantum uncertainty principle

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Special relativity

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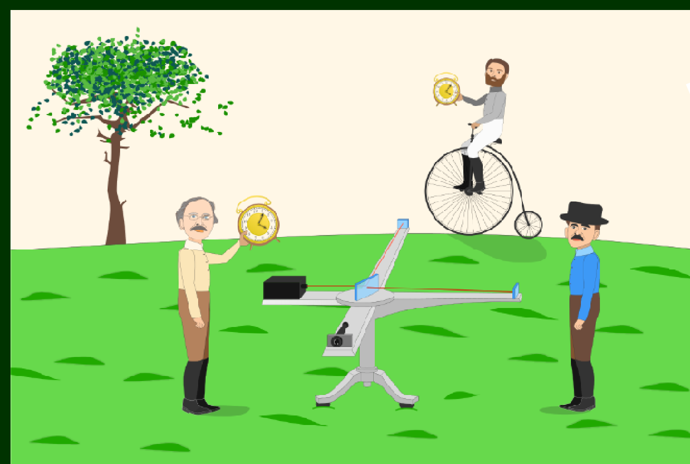
Quantum uncertainty principle



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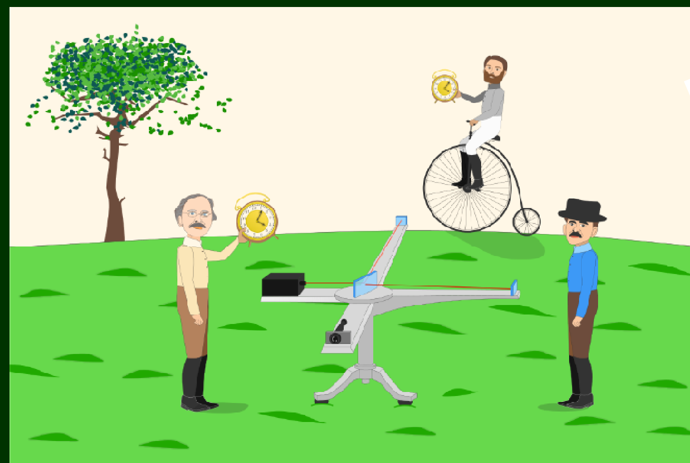

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Wave-particle duality

Axioms of the "Classical" physics

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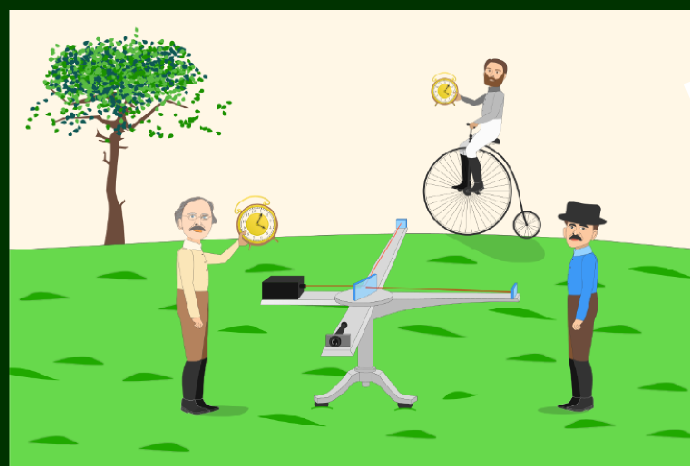
Quantum uncertainty principle

Time ... univ...al property

Special relativity



Any property of an object at a mome...
...ulated from the object's properties at one moment of time

Quantum uncertainty principle

The act of me...
...e of the object

Quantum state collapse: the act of measurement changes the state

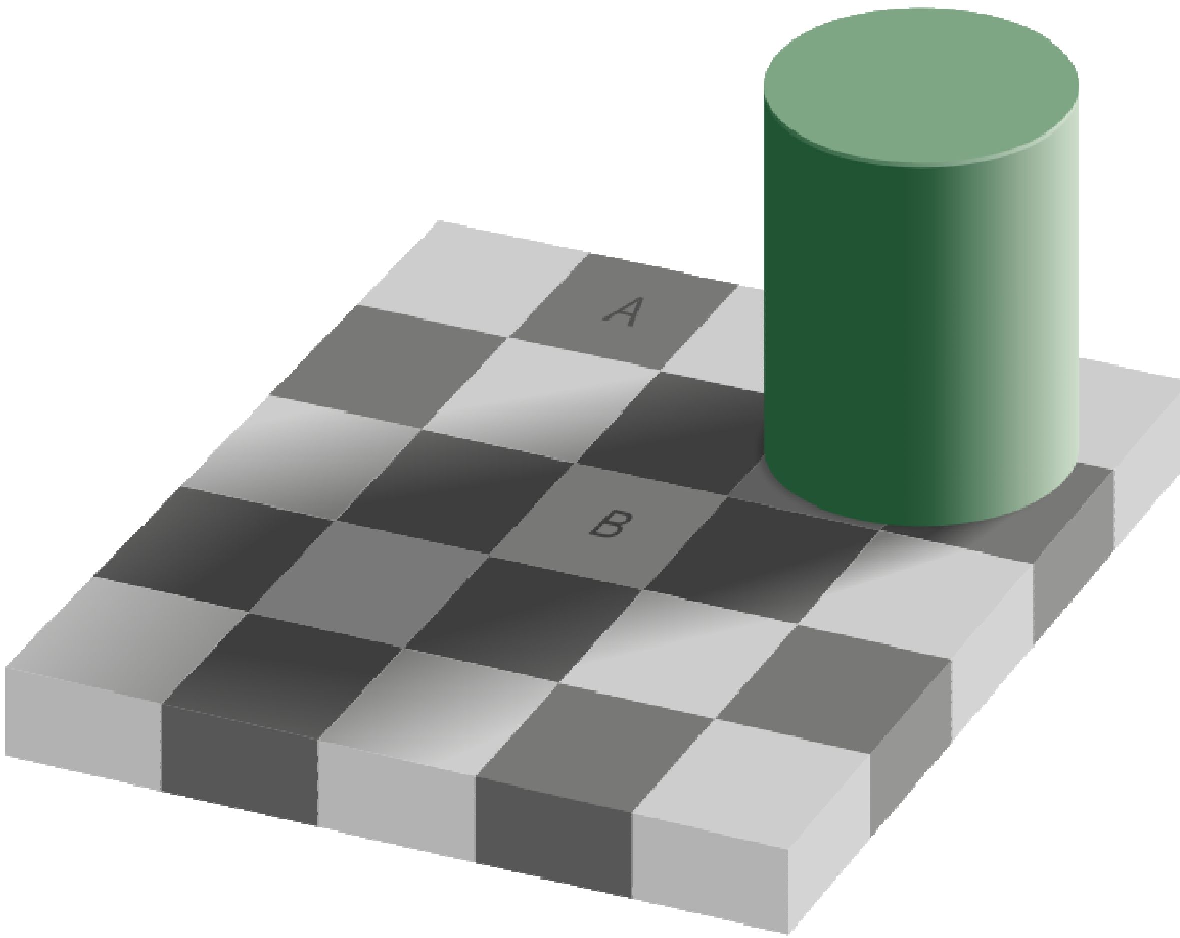
All matter can be describe... a collection of particles. Collecti...tion of such particles can b...scribed as a wave, a delocalized oscillation of a matter.

Wave-particle duality

Why this course is challenging?

- The effects we are going to discuss are outside of our everyday experiences.
- We have no intuition to guide us.
- The correct solution may seem as weird as any incorrect one.

Which square is darker: A or B?



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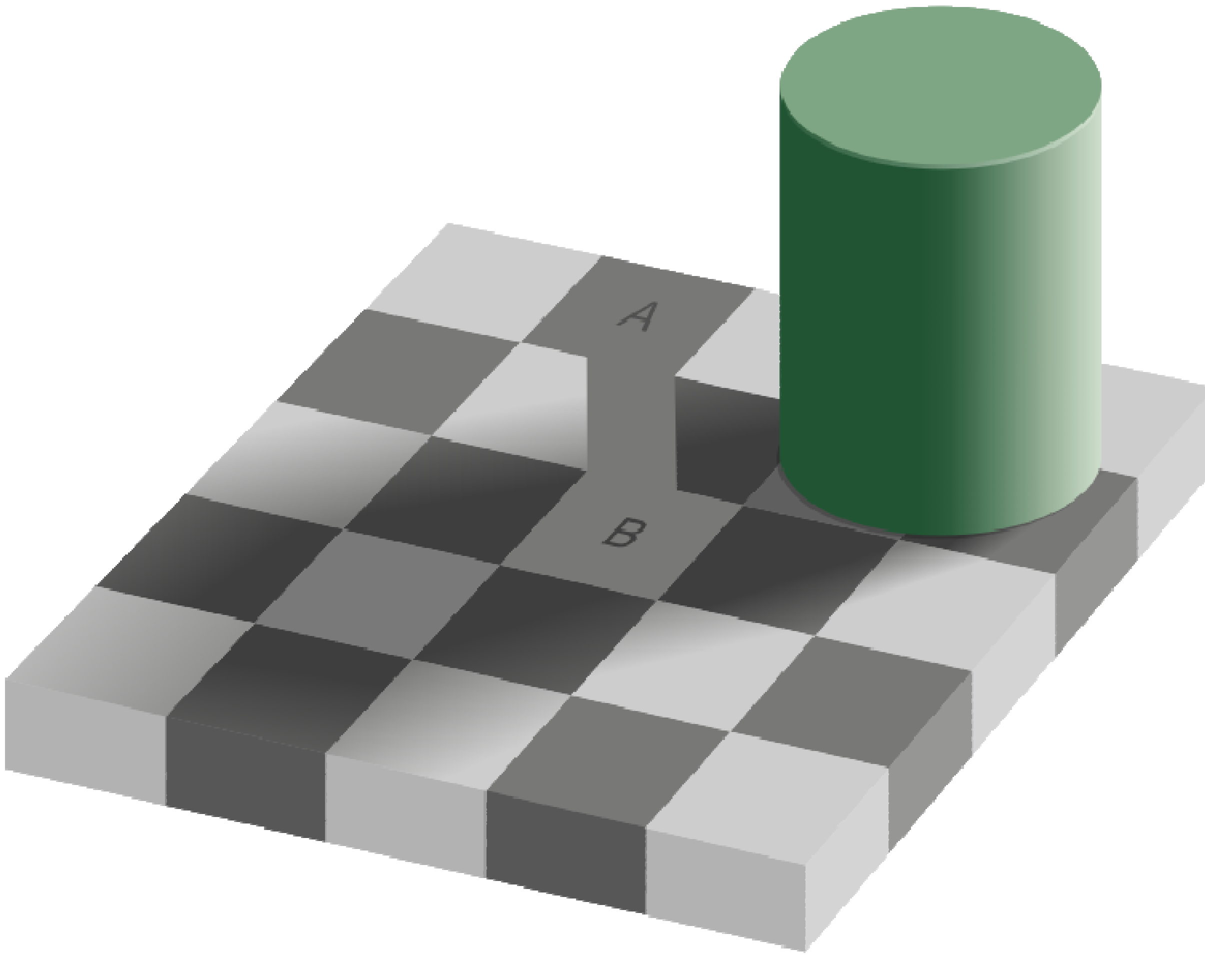
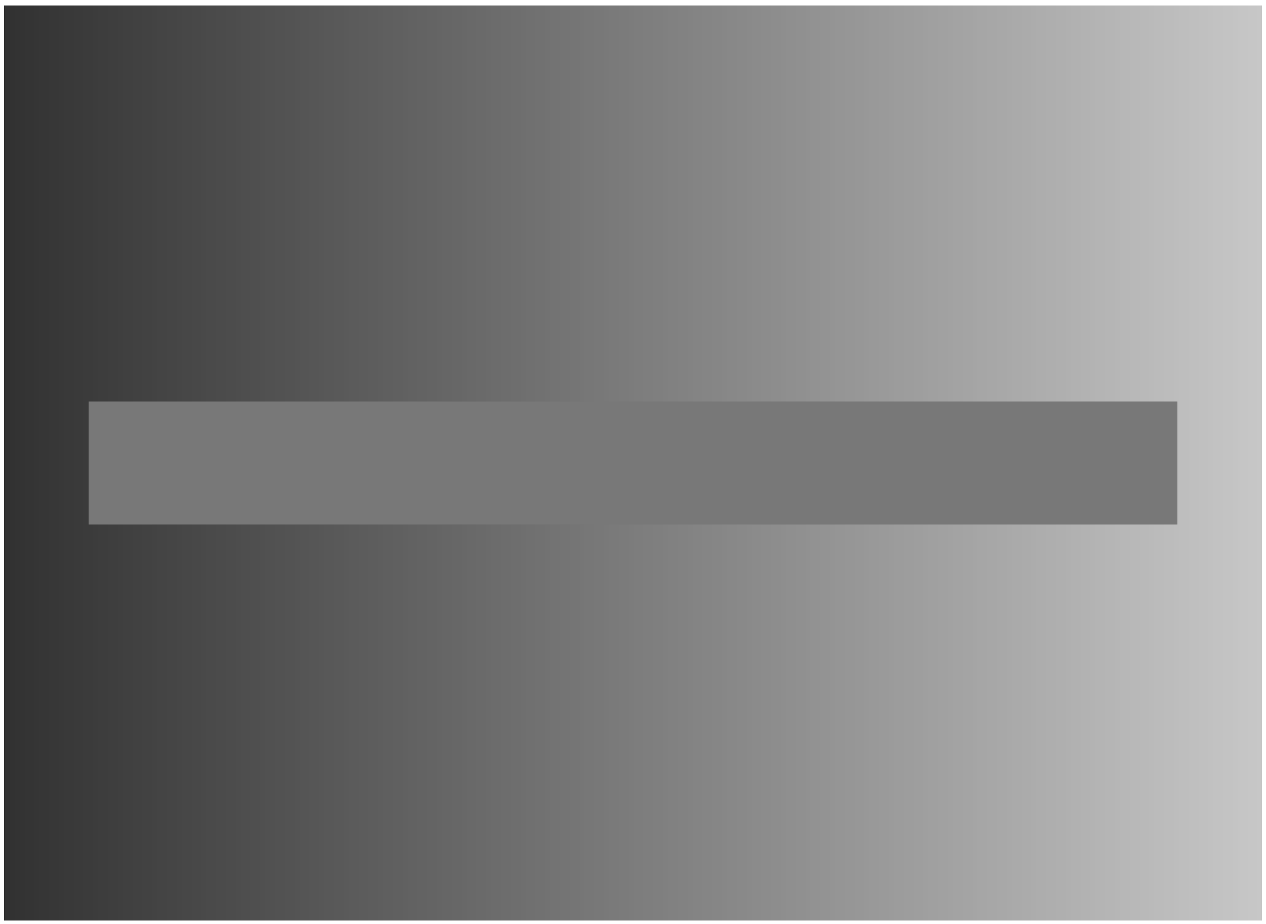


Which end of the strip is darker?



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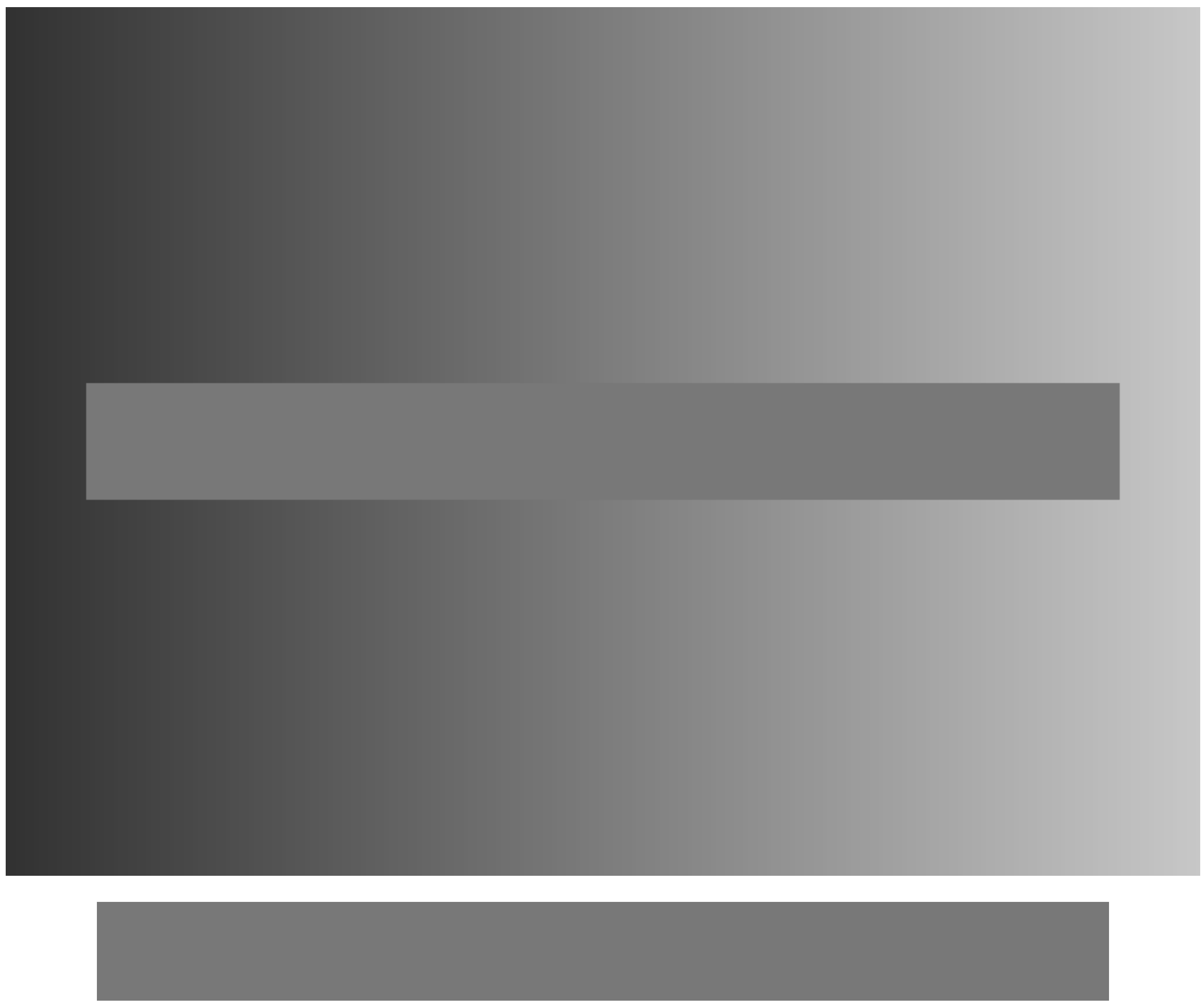

So, you see why this course is challenging?

People Aren't Dumb. The World Is Hard.

R. H. Thaler, father of behavioral economics

So, you see why this course is challenging?

People Aren't Dumb. The World Is Hard.

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Students Aren't Dumb. The Physics Is Hard.

I. Novikova, Modern Physics instructor