WELCOME TO PHYSICS 1020: “CONCEPTS of PHYSICS”
Your instructor:
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The rules

1. **You** are responsible for your grade. Come to class, think about the assignments and study!

2. **No excuses** will be accepted at the end of the semester. Your grade will be determined by your performance on assignments and exams only.

3. **Be courteous**: Be here on time, switch off your cell phone, do not walk inside the classroom...

4. Exams: Three midterm exams and the final. No make-up exams. One (worst) of the midterm exams scores will be dropped.

5. Homework and reading quizzes will be assigned sometimes due at 5 a.m. worth 5% of the grade. To be able to complete you need your Wayne State ID and access to the Blackboard.

6. Lab for those who registered for it.
PHYSICS
What is PHYSICS?

the nature of things as we see (observe) them at the present time.

The goal is to understand the world!

Understand? We are watching the game and trying to figure out the rules.

To figure the rules we use the scientific method.
PHYSICS is the most fundamental of the sciences

Chemistry: structure, interactions, and properties of matter on the atomic level (physics of electron interactions)

Biology: study of living organisms

Astronomy: the study of celestial objects, their motion, interactions, etc.

Geology: study of Earth

Psychology: study of processes in the brain
Scientific method has its own value since it may be your most powerful tool in analyzing everyday situations and making decisions.

Alternatives: complete ignorance, or faith
Why learn Physics?

1. To appreciate the **scientific method** and be able to use it in everyday life. Besides, physics plays into almost everything we do every day: Driving a car, flying, cooking or refrigerating food, electricity, energy use, sports etc.

2. To appreciate the **history of human ideas**: Physical theories rank amount the greatest achievements of the human mind. They reveal the astonishing order of the universe.

3. To appreciate the **beauty** of both, the universe and the physical theories.

4. Out of curiosity

    "The most incomprehensible thing about the universe is that it is comprehensible." after A. Einstein
Democritus (460-370 BCE.)
Galileo (1564-1642)
Sir Isaac Newton (1643-1727)
Michael Faraday (1791-1867)
J.C. Maxwell (1831-1879)

Albert Einstein (1879-1955)
Niels Bohr (1885-1962)
W. Heisenberg (1901-1976)
R. Feynman (1918-1988)
S. Weinberg (b. 1933)
So, what is science?

- A body of knowledge about nature and how it works.
- A method of exploring nature.
- Something that scientists do to create new medicines, computers, or other applications.
What is the “scientific method”?

Actually, there is no such thing as the scientific method. Scientists use a variety of methods to arrive at testable and reasonable theories about nature.

The book says:

The scientific method starts with an observation, then a hypothesis is formed which is supposed to explain the observation, the hypothesis is then tested by further experiments.

Observation -> Hypothesis -> Experiment

But this is a very antiquated way of thinking about it!
This is what you might have learned in high-school:

- Observation
- Hypothesis is not correct
- Hypothesis seems correct
- NO
- YES
- Formulate new hypothesis
- Devise experiment to test hypothesis
- Does outcome confirm hypothesis?
What’s wrong with this picture?

• Scientists don’t just ‘observe’ random things, they often start with a well-designed experiment.

• What makes a hypothesis plausible? How do we come up with a hypothesis?

• In fact, the discovery does not have to start with an observation!

⇒ What’s missing is that scientists work within some reasonable framework.

This framework is called THEORY.

**NOTE:** In science, “theory” is not just some “guess”, as in “this is just a theory”. 
Theory

Scientific hypothesis suggests an explanation of an effect within a theory

Experiment designed to observe an effect

Scientific hypothesis predicts an observation

An observation

Does it explain?

Yes    No

The experiment must be improved and/or the theory is limited and has to be redesigned

Validates the hypothesis and the theory
Paradigm: Current theory that explains the natural phenomena

An observation that cannot be explained by the current theory

The experiment is flawed

The theory is incomplete and must be improved

This is where new math methods are developed

New paradigm that includes the found effect

Improve the experiment and readdress the issue

This is where new technologies are designed
Requirements for the key components

- Observation
- Hypothesis
- Theory
- Experiment
Examples

- I observe that the sky is blue, but it changes during the sunset.
- I observe two stars. One of them looks white, another orange.
- I look at the vortex when the water is draining out of my tub, and notice that it is clockwise.
- A trustworthy friend tells you he saw a UFO last night hovering above his house.
- They say that if at the sunset the west is clear, it would be nice weather the following day.
- They say that that the heavier the object, the faster it falls.
Conditions for an observation to be scientifically useful:

- **Repeatability**: Is the phenomenon repeatable or is it “a miracle”? Do the same conditions lead to the same observation?

- **Physical evidence**: Is there some physical evidence of the observation, or is it just hearsay?

- **Clear description**: Is the description vague? Is the observation quantifiable?
Are scientists prejudiced?

Consider several examples:

1. Your car does not start in the morning. Where would you look for an explanation? (Troubleshooting)
   The reason must be electro-mechanical

2. You observe a sun eclipse. What could be a reason?
   Something must be preventing the light to go through, something must be in the way (some non-transparent object)...

3. You put a fresh egg in a fire, it blows up.
   The reason must be within the realm of thermal and mechanical phenomena...
Conditions for an explanation (hypothesis) to be scientific:

- **Testability**: Can the explanation be tested? Is it falsifiable?
- **Compatibility**: Is the explanation compatible with established theory?
- **Occam’s razor**: Is the explanation as simple as possible? Does it contain unexplained claims?
- **Appropriateness**: “Extraordinary claims require extraordinary evidence”

**Note**: The first one is a rule, the others are guidelines only.
The Physical Theory is a structure of ideas formulated as laws (rules) of Nature and their connections. The physical theory must be
1. Falsifiable, testable
2. self-consistent
3. Predictive, testable
4. “Minimalistic” in Occam’s sense.

The physical law is a steady repetitive relation between the physical objects, agents, or values that can be verified within certain limitations. (Newton’s laws...)

Postulate: a statement used in the PT without proof, validation of the theory vindicates postulates, but does not prove them (Fermat principle, Causality pr.)
Need clear description of an event in order to understand it, need a **measurement**.

**Measurement =**
- quantitative determination of a property
- Comparison of two (or more) subjects having the same property

1. Need a tool that has the same property as the one you want to measure!
2. Calibration, **units**
QUESTION:

A piton (character) wants to measure his length. His fellow animals make suggestions:

1. Monkey: “Fold in twice, then your length will be equal to 2 halves, or 4 quarters, etc.”

2. Parrot: “I’ll walk by you and measure your length in my steps.” ... “38 parrots”

Which suggestion is a correct measurement?

The second is, it introduces the units of a measurement, the measurement of length.

The problem: the units have to be more universal...
To measure LENGTH we compare the length of the measured object with the length of a tool calibrated by a certain equivalent.

As a result, the measurement gives a number of units of length.

The measurement is meaningless without units.
Units of length, area, and volume

English (Imperial) units:

• used in US (“US customary system”)

• Examples: foot, inch, mile, gallon, ounce, pound, fluid ounce, etc.

QUESTION:

How many fluid ounces are in a gallon?

1. 32
2. 64
3. 128
4. 256
How about this one?

*How many cubic inches in a gallon?*

1. 1000
2. 600
3. 230.97 ✓ **Good number isn’t it?**
4. 80.84
5. 280.54
SI units (Metric system)

used everywhere in the world (except US), even in England!

Units of length: 1 meter (m) = 100 centimeters (cm) = 0.001 kilometers (km) = 1000 millimeters (mm) = ...

Area: 1 m² = 10000 cm² = 0.000001 km² = 10⁴ cm² = 10⁻⁶ km²

Volume: 1 m³ = 10⁶ cm³ = 1000 liters (l) = ...

Examples: 5’ 8” is about 174 cm, or 1.74 m

Soccer field is about 100 m long

The Empire State Building is 381 m tall

1 mile = 1.609 km

The Marathon distance is 26.2 mi or 42.195 km
In the metric system conversions are always powers of ten, such as 10, 100, 1000 etc.

Use 'prefixes':

- nano = $\frac{1}{1000,000,000} = 10^{-9}$
- micro = $\frac{1}{1000,000} = 10^{-6}$
- milli = $\frac{1}{1000} = 0.001 = 10^{-3}$
- centi = $\frac{1}{100} = 0.01 = 10^{-2}$
- deci = $\frac{1}{10} = 0.1 = 10^{-1}$
- kilo = $1000 = 10^3$
- mega = $1000,000 = 10^6$
- giga = $1000,000,000 = 10^9$
Going from one units to others:

Convert feet to meters: 1 foot = 0.3048 meters

Conversion factors:

\[
(\frac{0.3048}{1}) \text{ m/ft} = 0.3048 \text{ m/ft}
\]

\[
\text{or } (\frac{1}{0.3048}) \text{ ft/m} = 3.2808 \text{ ft/m}
\]

Convert 78 feet to meters:

\[
78 \text{ ft} \times 0.3048 \text{ m/ft} = 23.77 \text{ m}
\]

Convert 78 meters to feet:

\[
78 \text{ m} \times (\frac{1}{0.3048}) \text{ ft/m} = 255.91 \text{ ft}
\]
Now, about numbers...

- Tools set the accuracy:
  - If you are measuring a length of a desk using a tape measure, a reasonable accuracy could be $1/16''$, but not $1/64''$
  - If you are measuring a length of a football field, $1''$ is probably good enough.
  - If you are measuring the distance from Detroit to San Diego, you can easily round it to ten miles.

- Physical accuracy has its limits. You cannot improve the accuracy infinitely. There is always a physical limit related to the nature of measurement.