

# Physics I

Mateusz Krzyzosiak

## **office hours**

Tuesday 14.15–15.15

Thursday 10.00–11.15

## **email**

[m.krzyzosiak@sjtu.edu.cn](mailto:m.krzyzosiak@sjtu.edu.cn)

## **office**

439C (JI building)

# Contents

## **SUMMER SEMESTER**

what is physics?

kinematics

dynamics (equations of motion, periodic motion, work, kinetic and potential energy, conservation laws, rotational motion, rigid body, elasticity)

elements of fluid dynamics

gravitation

mechanical waves

## **WINTER SEMESTER**

electricity and magnetism, electromagnetic waves, elements of optics

# Physics

*studies*

**matter and interactions at the most fundamental level (from inside a tiny nucleus of an atom up to the vast expanses of the Universe)**

*...and tries to find*

**fundamental laws of nature which underlie physical phenomena**

*some other fields of science*

**chemistry** (properties of combinations of atoms)

**biology** (structure and function of organisms)

**sociology** (behavior of human groups)

**psychology** (behavior of a human individual)

# Models, Laws, and Theories

## MODEL

**mathematical (abstract) representation of a physical (real) system**

e.g. material point (particle), rigid body, point charge, ideal gas

## LAW

**mathematical relation between physical quantities  
(from experiment or theory)**

e.g. the ideal gas equation, Kepler's laws of planetary motion

## THEORY

**uses a model and initial assumptions (*postulates*) to deduce specific consequences or laws**

e.g. Newton's theory of gravitation explains both: the falling of an apple and motion of planets

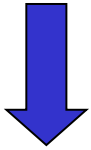
contrary to a common belief, theories do not always follow from experiments (e.g. *the heliocentric model*)

# Role of Experiment

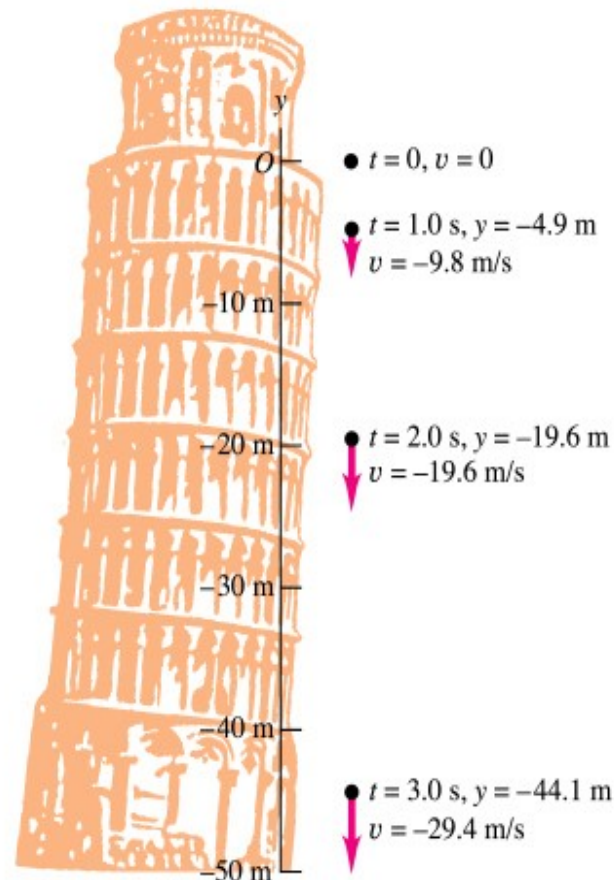
**OBSERVATION**



**EXPERIMENT**



**MEASUREMENT**



Copyright © Addison Wesley Longman, Inc.

It is said, that Galileo studied motion of free falling bodies by dropping them from the Leaning Tower in Pisa

# Theory and Experiment

An experiment is the ultimate test for all theories!

**No amount of experimentation  
can ever prove me right;  
a single experiment can prove me wrong.**

Albert Einstein

Physics is **experimental science!**

# Development of Physics



**Aristotle** (ca. 340 BC)

*"Since the box eventually stops, it must need something to keep it moving."*

**Galileo** (ca. AD 1600)

*"If one could eliminate friction, the box would move on forever."*

**The latter statement can be regarded as a scientific statement**

# Development of Physics: Example

**deeper understanding of nature  $\Leftrightarrow$  simplification of physical rules**

## **ancient times**

interactions between charged bodies (rubbed amber attracts pieces of paper)  
and between magnetized bodies (magnetite attracting tiny pieces of iron);  
qualitative statements

## **17<sup>th</sup> century**

quantitative approach: Coulomb's Law

## **19<sup>th</sup> century**

- interaction between electric current and a magnetic needle (Oersted)
- force between current-carrying conductors (Ampere)
- electromagnetic induction (Faraday)
- **unified theory of electromagnetic phenomena (Maxwell's equations)**

**Maxwell's Equations (four only!) comprise all laws of electricity and magnetism.**

**„ToE” theory of everything...?**



# Classical and Modern Physics

## **Classical Physics** (~ before the 20<sup>th</sup> century)

**Mechanics**

**Classical Thermodynamics**

**Electrodynamics**

## **Modern Physics** (since the 20<sup>th</sup> century)

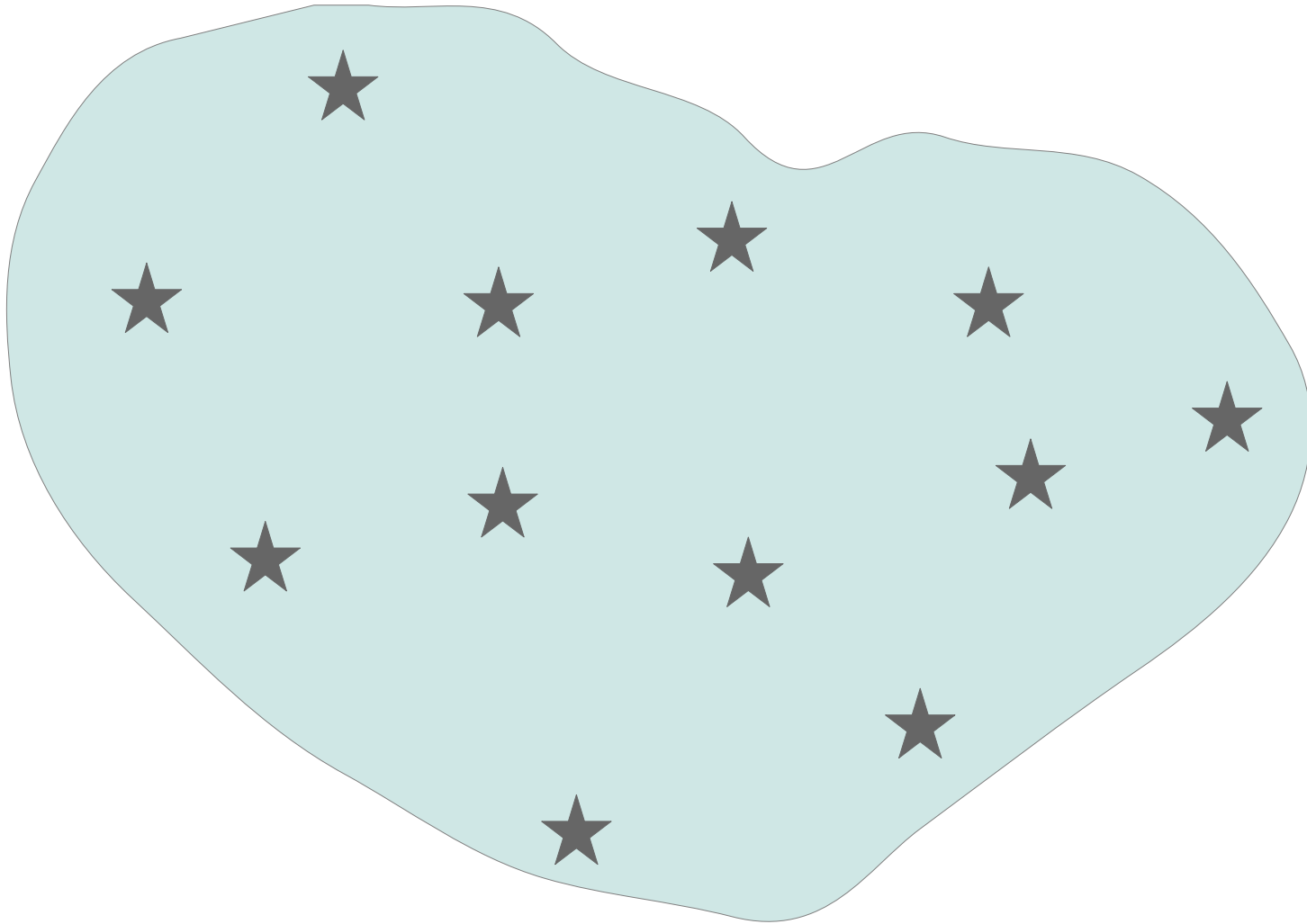
**Special Relativity**

**General Relativity**

**Quantum Mechanics**

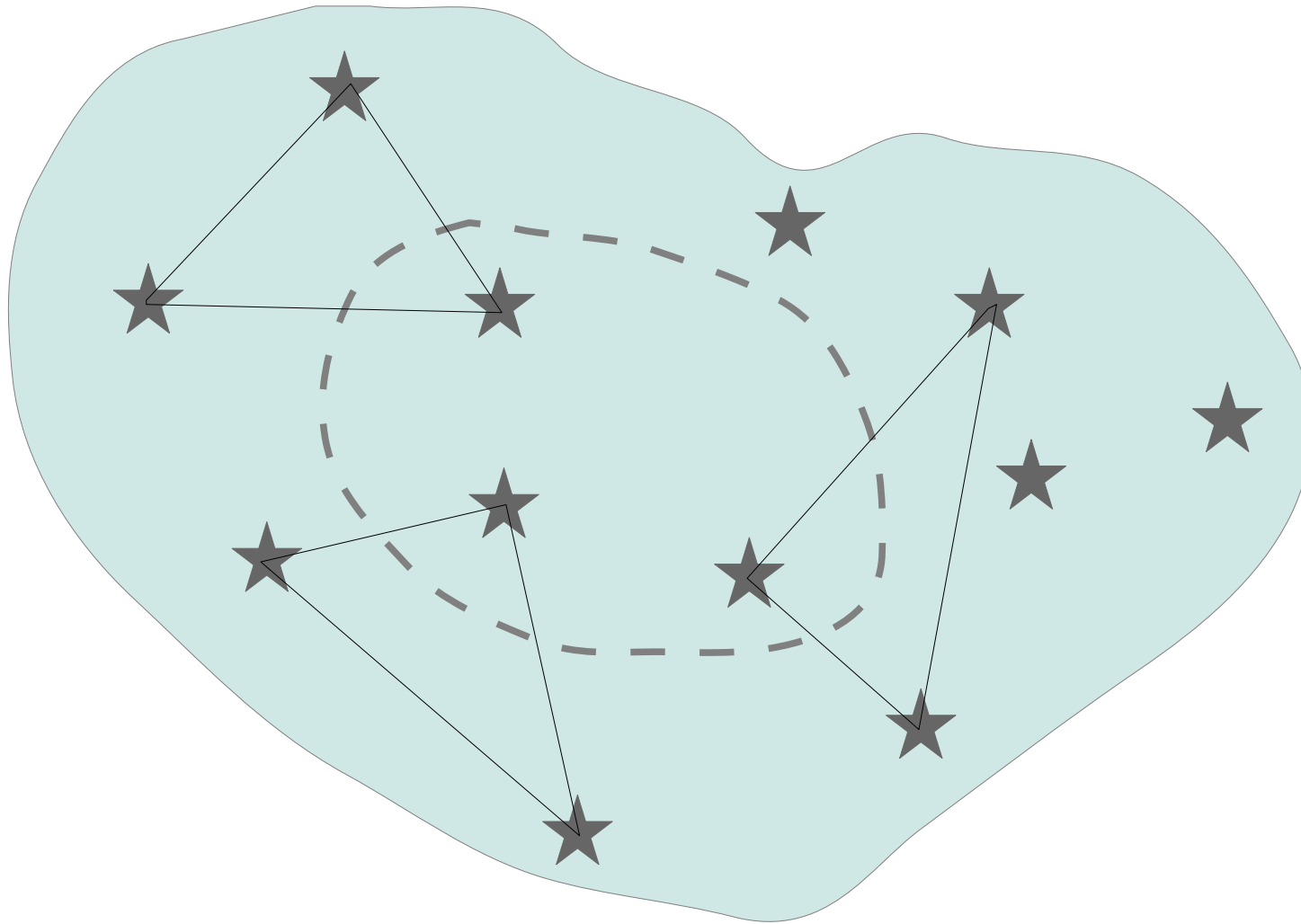
**Quantum Electrodynamics**

# Formulas and “Triangulation”



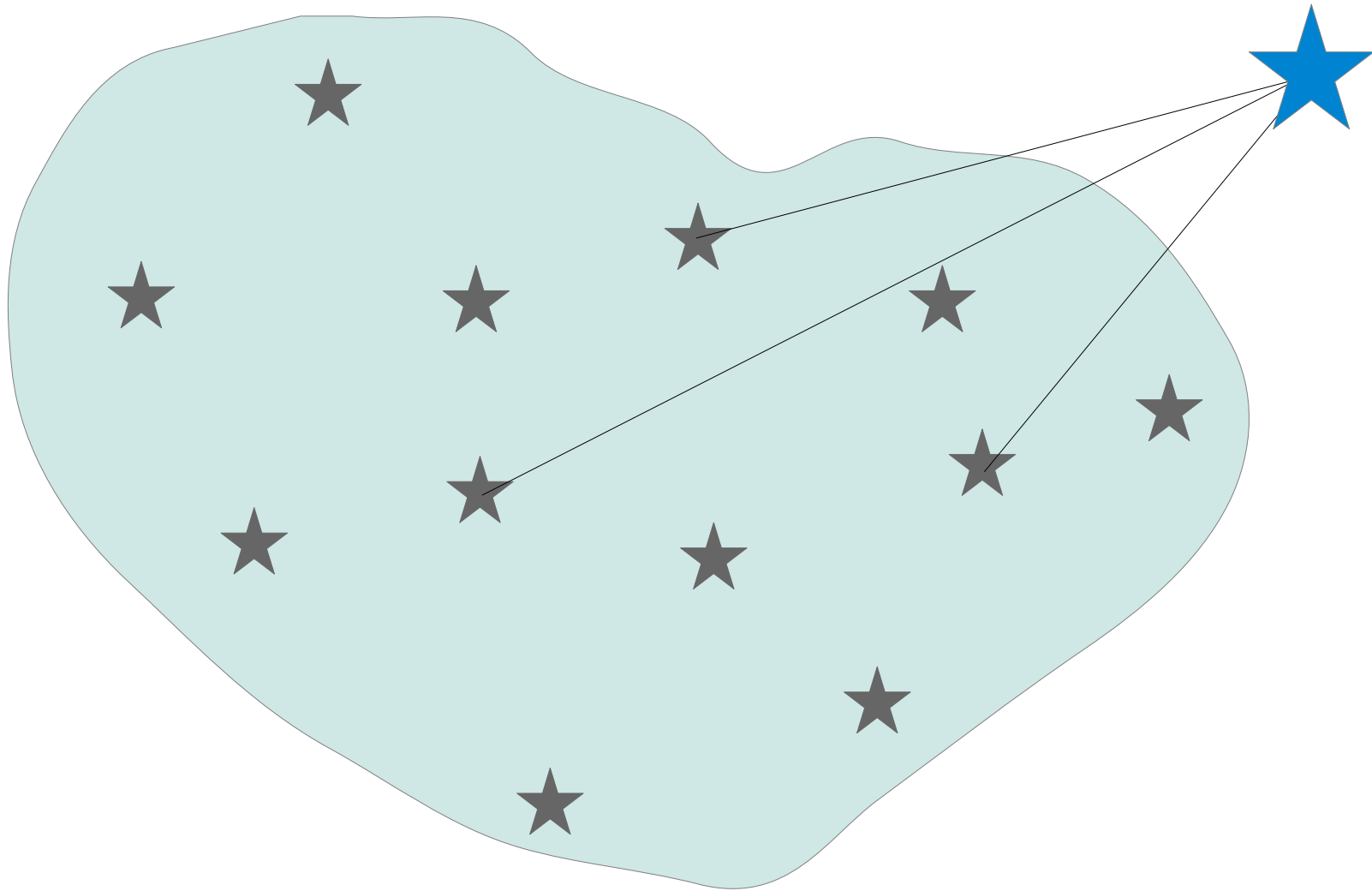
imaginary map of all the physics formulas

# Forgotten Facts Re-created



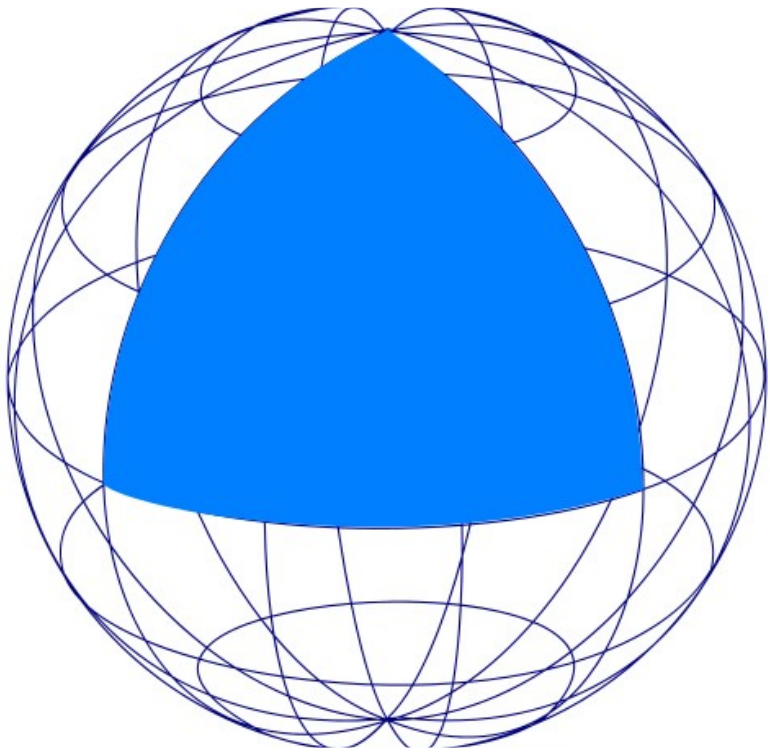
forgotten facts can be recreated by triangulating  
from known facts

# New Discoveries Made

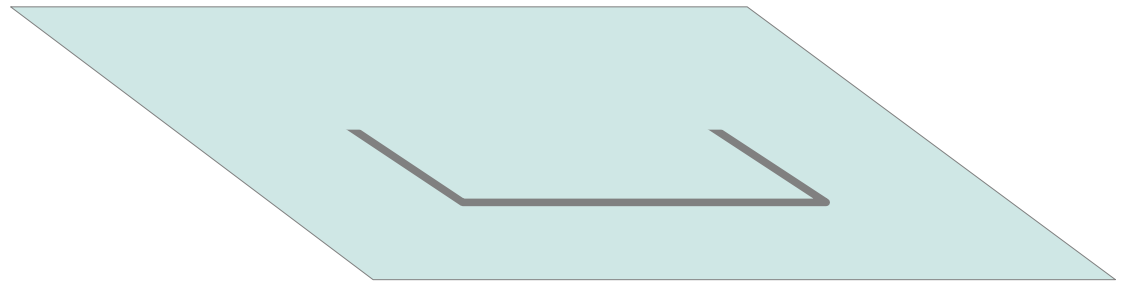


new discoveries are made by physicists triangulating from the known to the previously unknown

# Some Properties of Space...

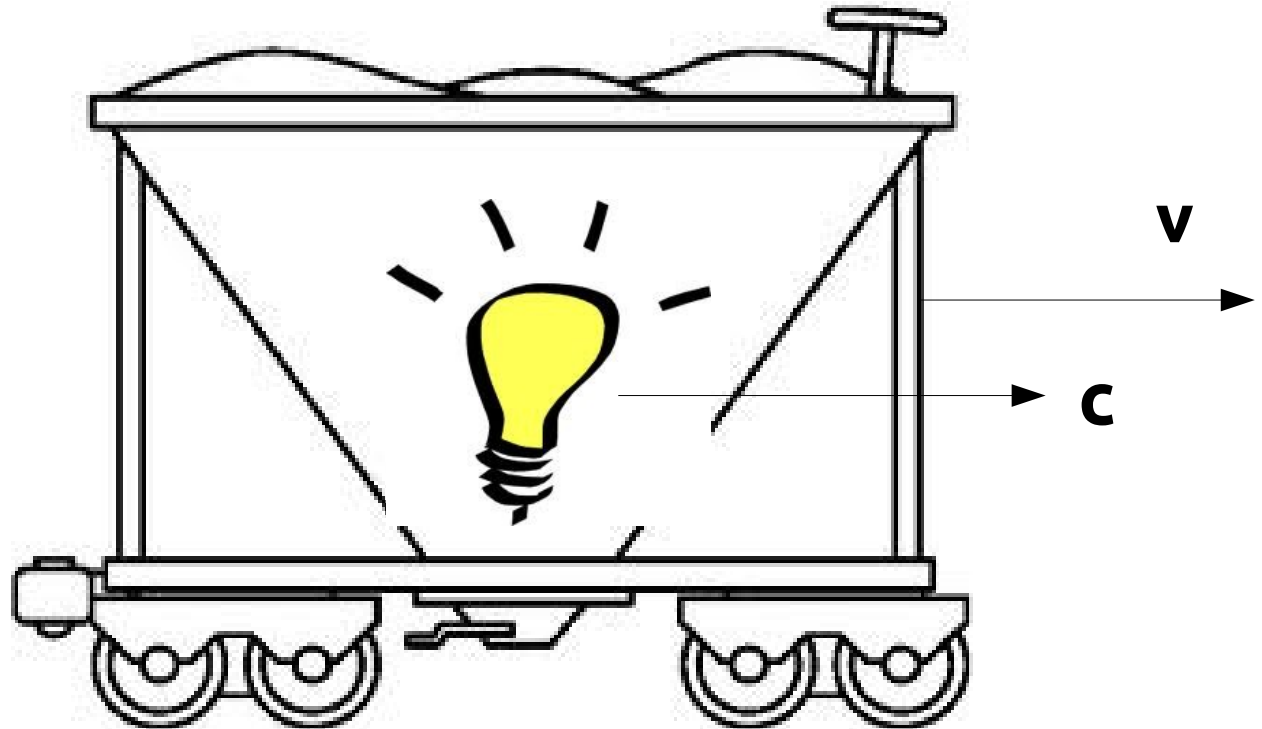


sphere:  
non-Euclidean two-dimensional space



plane:  
Euclidean two-dimensional space

# ...and Time



**Observation:** light still propagates at speed  $c$ ;  
**Implication** (one of many): time is relative!

**Don't be afraid to think beyond your horizons!**

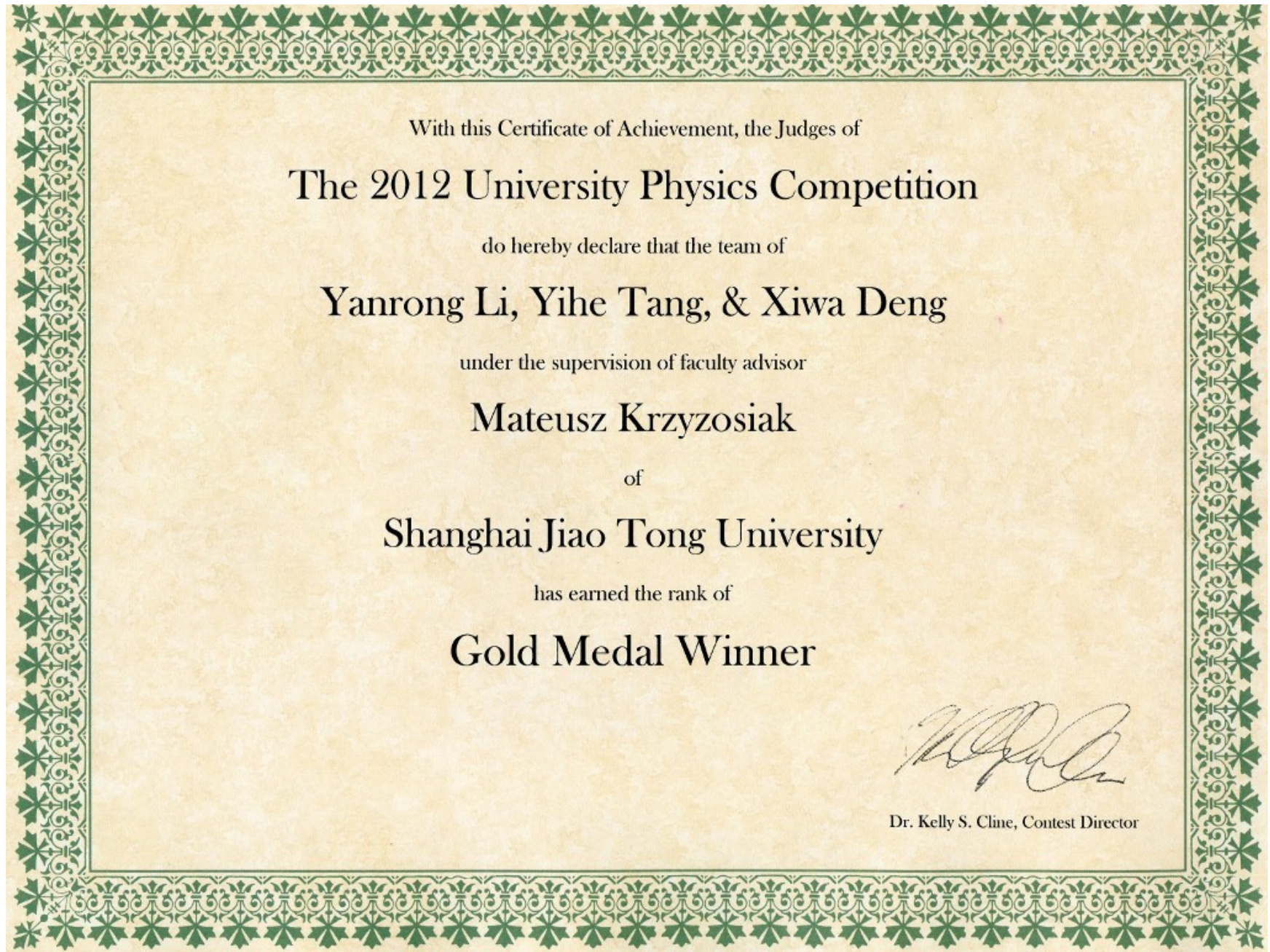
# University Physics Competition

The University Physics Competition is an international contest for undergraduate students, who work in teams of three at their home colleges and universities all over the world, and spend a weekend in November (48 hours) analyzing a real-world scenario using the principles of physics, and writing a formal paper describing their work. **The 12<sup>th</sup> University Physics Competition will take place in November 2021.**

**[www.uphysicsc.com](http://www.uphysicsc.com)**



# University Physics Competition



With this Certificate of Achievement, the Judges of

## The 2012 University Physics Competition

do hereby declare that the team of

**Yanrong Li, Yihe Tang, & Xiwa Deng**

under the supervision of faculty advisor

**Mateusz Krzyzosiak**

of

**Shanghai Jiao Tong University**

has earned the rank of

**Gold Medal Winner**

Dr. Kelly S. Cline, Contest Director



With this Certificate of Achievement, the Judges of  
The 2019 University Physics Competition  
do hereby declare that the team of  
Fang Yigao, Chen Siyi, Shen Qi  
under the supervision of faculty sponsor  
Mateusz Krzyzosiak  
of  
Shanghai Jiao Tong University/Joint Institute  
has earned the rank of  
Gold Medal Winner



Dr. Kelly S. Cline, Contest Director