TOPICS IN THE HISTORY OF MODERN MATHEMATICS (MHF4401)

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Course Theme

The proposed course focuses on the life, the achievements, and the historical times of three scientists whose theories have deeply impacted the development of the science, the society and the culture of their time and our time: Galileo (1564-1642) Newton (1643 – 1727) and Einstein (1879 - 1955).
Wewill start with Galileo's famous falling body experiment, then will move to Newton's formalization of the laws of gravitation, and then to Einstein's theory of special and general relativity, which include a redefinition of the gravitational force. Galileo, Newton and Einstein had a global impact on the science and the society and the culture of their times. In this course, the students will examine the life and work of these scientists from a multicultural and sociological perspective and will understand how economical and sociological reasons and prevailing world conditions have shaped up the life and the works of these scientists. One of the key ideas of Einstein's general relativity is that gravity is not an ordinary force, but a consequence of the curvature of the space-time. In order to present the mathematics behind Einstein's gravitation theory to the students, we will provide a crash course in differential geometry and non Euclidean geometries.

Global Learning Outcomes addressed

Global awareness

- Students will demonstrate knowledge of how the most significant developments in modern sciences originated as global answers to interrelated problems posed by different cultures and civilization through the centuries.

In this class the students will learn how progress and discoveries in sciences are made possible when scientists of different civilizations and cultures get acquainted and find solutions to common problems. For example, Einstein's theory of special relativity was preceded by many theoretical results and empirical findings obtained by Albert Michelson, (an American physicist known for his work on the measurement of the speed of light) Hendrik Lorentz, (a Dutch theoretical physicist), Henri Poincaré (a French mathematician and physicist) and others. These scientists came from different nations that were deeply politically divided and soon to be at war with each other, but the common scientific interests overcame any cultural and political difference between them. The subsequent work of Max Planck (a German physicist who is regarded as the founder of the quantum theory) Hermann Minkowski (A Lithuanian mathematician, who created and developed the geometry of numbers) and others was made possible by the new understanding of space and time and the electromagnetic forces. These are just examples that illustrate how progress and discoveries in sciences are made possible when scientists

of different civilizations and cultures get acquainted and find solutions to common problems. Students will learn how the most significant developments in sciences originated as global answers to interrelated problems posed by different cultures and civilization

Global perspective

- Students will be able to conduct a multi-perspective analysis of the economical and sociological reasons of different approaches to the theory of gravitation through history and nowadays.

A genuine appreciation of the historical development of science involves some degree of understanding of the scientific theories, as well as the study of the surrounding history and culture and the lives of those who formulated these theories. Understanding the problems and the perspectives of different cultures and comparing their approaches to logical thinking and problem solving is a very important component of this class.

The theory of gravitation was mostly developed by three scientists whose life and discoveries were deeply impacted by the society and the culture of their time. For example, Galileo's astronomical discoveries contributed to support the heliocentric theory of Copernicus, a German scientist, but were in stark contradiction with the scientific and philosophical ideas supported by the Church. Galileo had to hide his work for a longtime, and had to stand trial on a grave suspicion of heresy. Newton's life was impacted by the civil war in England; he wrote his best work at the time of the London great plague and was accused of plagiarism by Leibnitz, a German scientist with a completely different background.
By understanding the different economical, political and sociological conditions of the society at the time of Galileo, Newton and Einstein, the students will gain a better perspective of how their vision of science originated and how it is understood nowadays.

Global engagement

- Students will be able to provide modern solutions to ancient problems and compare their solutions with the modern ones.

Students will solve problems that are inspired by problems solved by Galileo, Newton and Einstein, and will compare the "old" solutions with the "modern" ones. In this process, they will be able to understand and interpret the interrelation between certain techniques in mathematics and concepts of Physics, and the needs that the society where such techniques were used had at the time. For example, Galileo's study of gravitation was encouraged by the Pope's military advisers who needed to calculate with accuracy the trajectory of cannon balls. Many more examples will be used to explain how the needs of various civilizations shaped up the modern Mathematics and Physics into a truly global science.

Course Rationale

This class will provide a global perspective of the history and development of the theory of gravitation and the mathematical techniques used to develop the theory from the 15thto

the 20th century. FIU undergraduates will understand and interpret the interrelation between the scientific theories learned in class and the needs that the civilizations were such techniques were used and developed had at the time. They will demonstrate knowledge of how the specific topic originated as global answers to interrelated problems posed by different cultures and civilization through the centuries, and will conduct a multi-perspective analysis of the economical and sociological reasons of different approaches to the specific topic through history and nowadays.

Students will also acquire knowledge of interconnected conditions and the ability to analyze issues related to the life and work of the scientists who shaped up the life and the culture of their time from multiple perspectives. The willingness to engage in interdisciplinary and intercultural problem solving will be required.

Assessment tools

This will be a "working course": there will be a strong focus on doing representative problems that will clarify and illustrate the development of the theory of gravitation and the mathematical techniques used to develop such theory. In addition, students will be required to take two midterms and a final, which will be composed of problems and essay questions. An individual or group project outlining a team project relating to class themes will also be required. The group will be assessed through a written presentation and a group discussion using assessment rubrics.

Textbooks

For the first part of the course I will use parts of the excellent textbook of J. Suzuki, *A History of Mathematics.* I will also use parts of *Introduction to Non-Euclidean Geometry* by Harold E. Wolfe, several chapters of *Riemannian geometry: a beginners guide* by F. Morgan, and *Space, Time and Gravitation: An Outline of the General Relativity Theory* by Arthur Stanley Eddington, Cambridge University Press, 1920, (available as e-books).

Other textbooks that I will use, although not heavily, throughout this course, are:
The Scientific Revolution: A Brief History with Documents, edited by Margaret C. Jacob.
Relativity: The special and general theory by A. Einstein, Methuen and co Ltd, 1924,*Space, Time and Gravitation: An Outline of the General Relativity Theory* by Arthur Stanley Eddington, Cambridge University Press, 1920, (this book is also available as e-books), and *A short history of England*, by Gilbert Keith Chesterton and Eric Gill".

Potential Co-curricular Activities

- Guest lecturers from the Departments of History. For example, Prof. Patrouch, who will provide a competent introduction to the history of England in the 16th century.

- Two educational NOVA videos. One is about Newton's life, discoveries, and secret coded diaries that were decoded only a few years ago. The other video will

illustrate the theory of relativity and the famous experiment of Michelson and Morley that proved that the speed of light is an absolute constant in nature.

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Weekly Schedule

week	Topics	Assignments	GL accomplishments
1	**A review of basic theory of gravitation. Introduction to Galileo**		
2	**Galileo and his time. A thorough description of the socio-economic conditions and the religious influence in the Italian society of the 16th century** **Copernicus and the heliocentric model of the solar system. Analysis of the socio-economic conditions and religious influence in the German society of the 16th century. Newton's life.**	**Homework 1. Basic problems on gravitation+ essay type questions on Galileo and Copernicus and their time.**	***(Global perspective)*** **Students understand how the prevailing economical and sociological conditions influenced Galileo's and Copenicus' lives and accomplishments.** ***(Global awareness)*** **Students learn how the understanding of the solar system originated as global answers to interrelated problems posed by the cultures and civilizations that shaped up the lives of Galileo and Copernicus.**
3	**Newton: The universal gravitation theory, the nature of light, and other accomplishments.** **A brief history of England in the 17th century. The civil war, the great plague. Analysis of the socio-economic conditions and religious influence in the British society of the 17th century.**	**Homework 2. Basic problems on gravitation+ essay type questions on Newton and the history of England.**	***(Global perspective)*** **Students understand how the prevailing economical and sociological conditions influenced Newton's life and accomplishments.** ***(global engagement)*** **Students will learn how to derive Galileo's equations from Newton's**
4	**More about Newton. Contribution of other scientists to the theory of gravitation. Huygens and his interpretation of the nature of light *(if time allows)* The controversy between Newton and Leibnitz.**	**Test in class**	***(Global awareness)*** **Students learn how the understanding of the nature of light and the universal gravitation originate as global answers to interrelated problems posed by the cultures and civilizations that shaped up the lives of Newton, Huygens and other scientists**
5	**An historical introduction to the non Euclidean geometries. Introduction to differential geometry**	**Homework 3. problems on differential geometry and non Euclidean geometry. Long questions on the genesis of the non Euclidean Geometries.**	***(Global awareness)*** **Students learn how the understanding of the non Euclidean models originate as global answers to the problem of the description of the universe posed by different cultures and civilizations throughout the centuries.** ***(global engagement)*** **Students will learn how to derive the equations of the Euclidean geometries from well known Calculus formulas.**

6	**A review of differential geometry**		

week	Topics	Assignments	GL accomplishments
7	**More on differential geometry.**	**Homework 4 on differential geometry.**	
8	**More on differential geometry. The speed of light and the Michelson-Morley experiment.** **History of the measurement of the speed of light.**		***(Global awareness)*** **Students learn how the measurement of the speed of light originate as global answer to a basic problems posed different cultures and civilizations throughout the century** ***(global engagement)*** **Students will learn how the problem of measuring the speed of light was approached in different times, and will compare the methodology used by different scientists at different times.**
9	**Einstein and his time. A brief history of Germany after the world war I. The advent of Hitler and the racial laws. Analysis of the socio-economic conditions in the Nazi Germany and their effect on Einstein's life and work.**	**Test in class**	***Global perspective)*** **Students understand how the prevailing economical and sociological conditions influenced Einstein's life and accomplishments.**
10	**Introduction to the theory of special relativity. Lorentz and Lorentz' equations.**	**Homework 5. problems on relativity. Long questions on Einstein's life, and the genesis of the theory of relativity.**	***(Global awareness)*** **Students learn how the understanding of the relativity of time originates as global answers to interrelated problems posed by the cultures and civilizations that shaped up the lives of Einstein, Lorentz, Michelson and Morley and other scientists .** ***(global engagement)*** **Students will learn how Galileo's and Newton's equations are a special case of Einstein's**
11	**Introduction to general relativity. The gravitational field.**		***Global perspective)*** **Students understand how the interpretation of the gravitation was affected by the prevailing economical and sociological conditions and the progress in technology at the time of Galileo, Newton and Einstein.** ***(Global awareness)*** **Students learn how the understanding of the gravitational force originates as global answers to interrelated problems posed by the cultures and civilizations that shaped up the lives of Galileo, Newton and Einstein.** ***(global engagement)*** **Students will learn**

			how the theory of general relativity originated as the product of the brilliant ideas of different scientists that lived in different countries and cultures. different cultures.

week	Topics	Assignments	GL accomplishments
12	**The equations of the general relativity for the gravitational field.**	**Homework 6. problems on relativity. Long questions on Einstein's interpretation of the gravitational field**	
13	**More on the equation of relativity. (if times allows) E= m c^2**		
14	**Review. Group discussion in class**		
15	**Review.**		