The 18^{th} Century Mechanical Universe

Mahn-Soo Choi (Korea Univ)

September 20, 2013 (v5.1)

Background image from EREPUBLIK: The New World

Image from Wikipedia

All That is Needed is an East Wind

Image from Wikipedia

Image courtesy of Universal Studio; (주)싸이더스FNH(제작) & CJ 엔터테인먼트(배급)

Image courtesy of (주)싸이더스FNH(제작) & CJ 엔터테인먼드(배급)

Image courtesy of Mark Gardiner (2011) / Asphalt and Rubber, Inc.

Image courtesy of China Foto Press / Barcroft Media

It's all about "predicting the future"!

It's all about "predicting the future"!

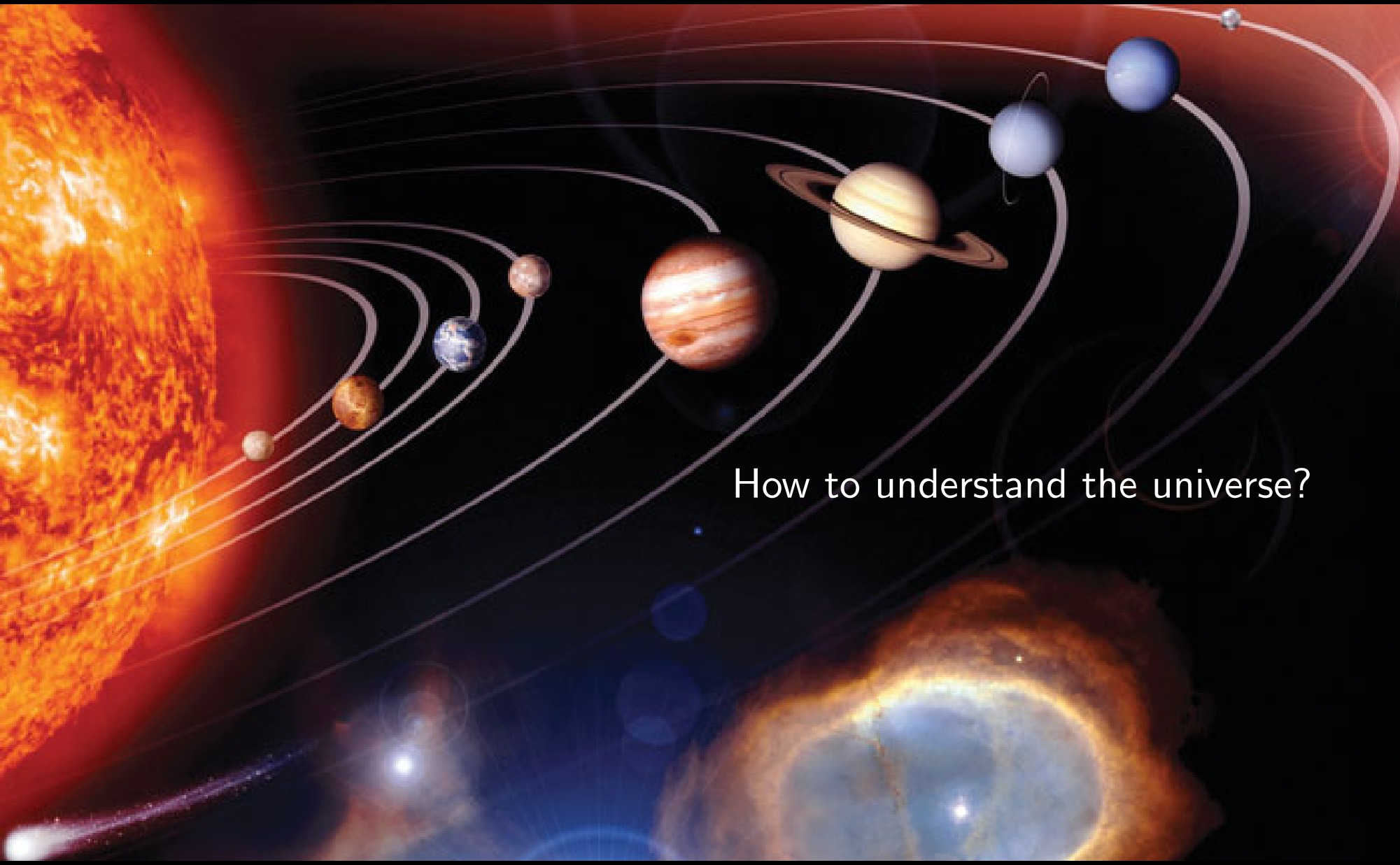
How can we predict the future?

Why is it so difficult to predict the future?

Image courtesy of Mark Gardiner (2011) / Asphalt and Rubber, Inc.

How to Predict the Future?

- To understand the fundamental principle.
- To apply it to the particular phenomena.



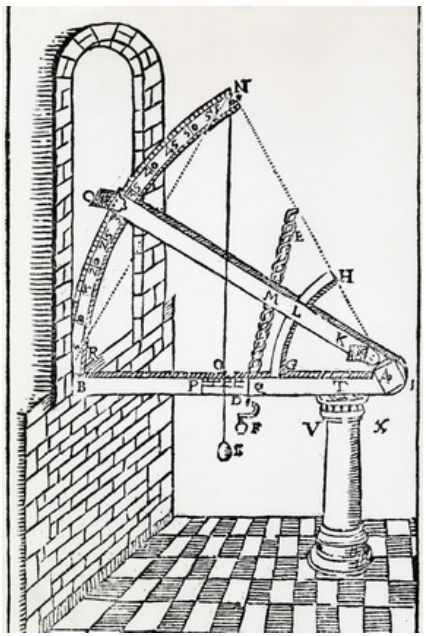
Background image from http://scienceclass.ning.com/

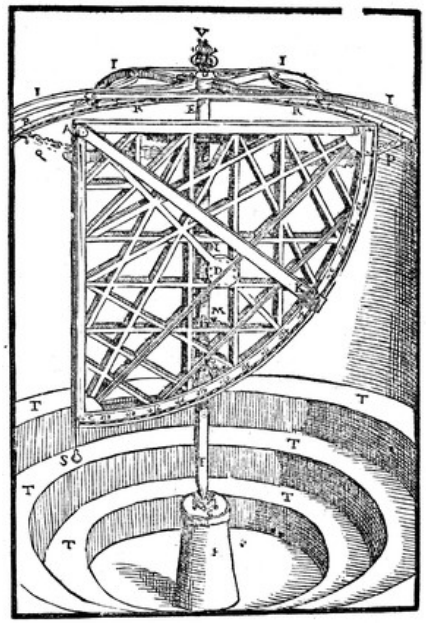
How can we predict the motion?

Background image from http://lynnmariecherry.blogspot.com/

Tycho Brahe (1546–1601)

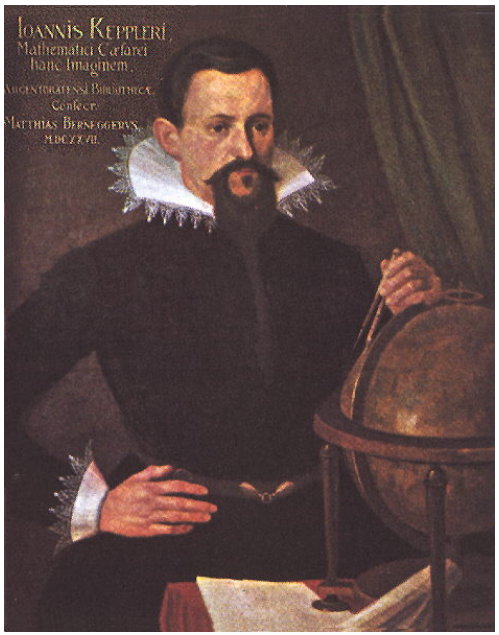
(the greatest pre-telescope observer)





Images from Source: Wikipedia

Johannes Kepler (1571–1630)



Johannes Kepler, *Tabulae Rudolphinae (Rudolphine Tables)* (1627)

Images from Source: Wikipedia

Kepler's Laws of Planetary Motion

(1909, 1919)

The 1st Law

The orbit of every planet is an ellipse with the Sun at a focus.

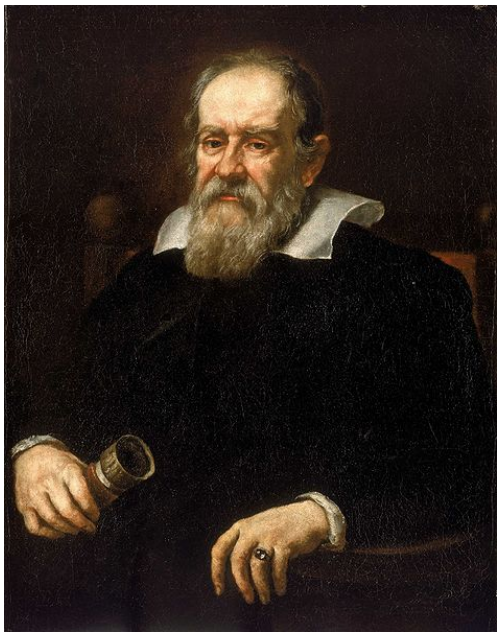
The 2nd Law

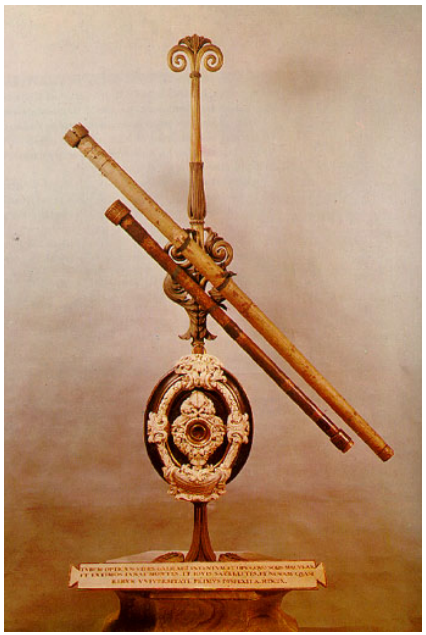
The line joining a planet and the Sun sweeps out equal areas during equal intervals of time.

The 3rd Law

The square of the orbital period of a planet is directly proportional to the cube of the semi-major axis of its orbit.

Galileo Galilei (1564-1642)

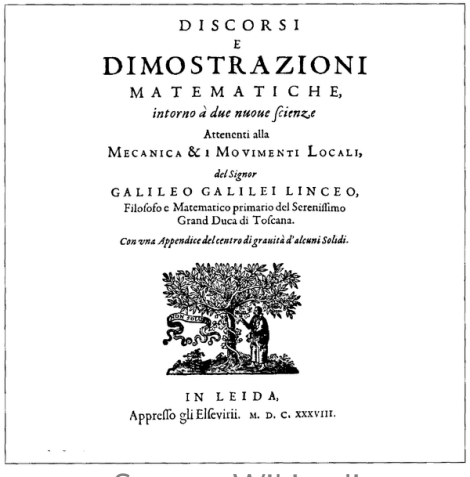




Images from Wikipedia

Galileo's Principle of Inertia

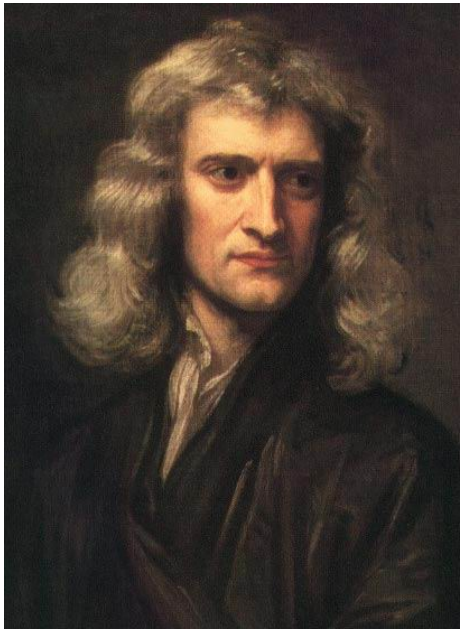
A moving will continue in the same direction at constant speed unless disturbed.

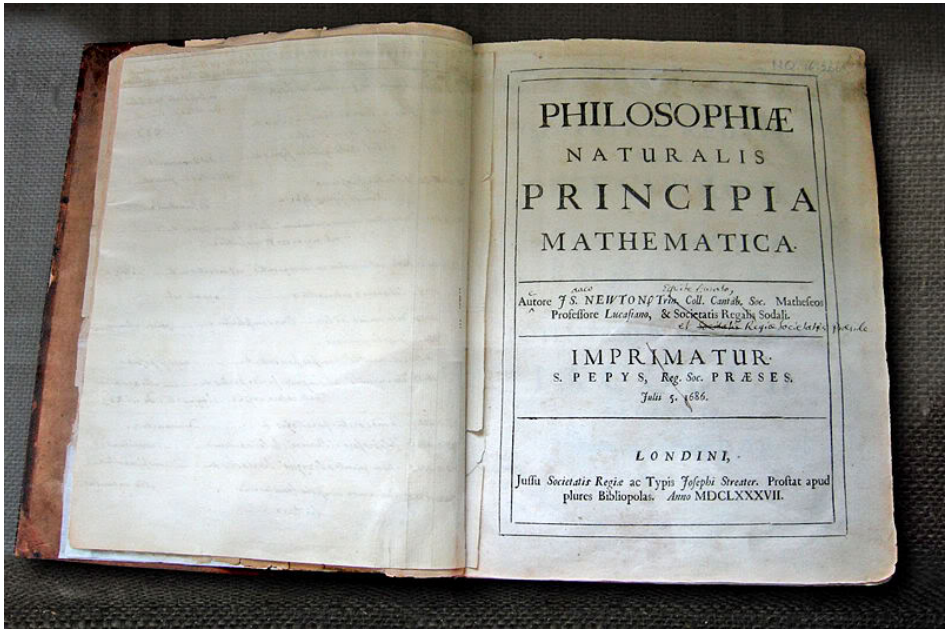

DISCORSI
E
DIMOSTRAZIONI
MATEMATICHE,
intorno à due nuoue scienze
Attenenti alla
MECANICA & I MOVIMENTI LOCALI,
del Signor
GALILEO GALILEI LINCEO,
Filosofo e Matematico primario del Sereniſſimo
Grand Duca di Toſcana.
Con vna Appendice del centro di grauità d'alcuni Solidi.
IN LEIDA,
Appreſſo gli Elſeuirii. M. D. C. XXXVIII.

Source: Wikipedia

Discourses and Mathematical Demonstrations Relating to Two New Sciences
(Discorsi e dimostrazioni matematiche, intorno a due nuove scienze, 1638)

Sir Isaac Newton (1643–1727)





Sir Isaac Newton, *Philosophiae Naturalis Principia Mathematica* (1726)

Right image from Wikipedia

Newton's Laws of Motion

(Newton, Philosophiae Naturalis Principia Mathematica, 1726)

Newton's 1st Law

If no *net* force acts on a body, the body's velocity cannot change.

Newton's Laws of Motion

(Newton, Philosophiae Naturalis Principia Mathematica, 1726)

Newton's 1st Law

If no *net* force acts on a body, the body's velocity cannot change.

Newton's 2nd Law

The net force on a body is equal to the product of the body's mass and its acceleration:

$$(\text{force}) = (\text{mass}) \times (\text{acceleration})$$

Newton's Laws of Motion

(Newton, Philosophiae Naturalis Principia Mathematica, 1726)

Newton's 1st Law

If no *net* force acts on a body, the body's velocity cannot change.

Newton's 2nd Law

The net force on a body is equal to the product of the body's mass and its acceleration:

$$(\text{force}) = (\text{mass}) \times (\text{acceleration})$$

Newton's 3rd Law

When two bodies interact, the forces on the bodies from each other are always in magnitude and opposite in direction.

Scientific Determinism

(Laplace 1902)

We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, if this intellect were also vast enough to submit these data to analysis, it would embrace in a single formula the movements of the greatest bodies of the universe and those of the tiniest atom; for such an intellect nothing would be uncertain and the future just like the past would be present before its eyes.

Image from http://www.pjcj.net/

References

P. S. Laplace, *A philosophical essay on probabilities*, (J. Wiley, New York, 1902).