

THE GEARS OF THE ANTIKYTHERA MECHANISM: AN EDUCATIONAL PATHFINDER TO THE SOLAR SYSTEM

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The gear of the Sun

Abstract. The Antikythera Mechanism is the most sophisticated ancient astronomical instrument and analogue calculating machine known to the scientific community. It is the most sophisticated device from the ancient Hellenic world constructed somewhere between 150 and 100 B.C., almost a century after the death of Archimedes. The Mechanism has great educational potential: it appeals to inquiring minds as an astonishing artefact of science and technology. The latest research findings reveal significant cultural and social function in its operation (Freeth *et al.* 2006; Freeth *et al.* 2008). This astonishing astronomical instrument possesses an interdisciplinary value. It has recently been proposed that this ancient device, known as the world's first computer, may be used as an educational medium to engage the general public and especially to attract students to both the exact sciences and to the humanities. The astronomical and technical knowledge embedded in the Mechanism could also be used to approach some aspects of modern science through the unknown technological achievements of Hellenic antiquity.

Keywords. Antikythera Mechanism, astronomical instrument



prediction of an eclipse

1. Introduction. The Antikythera Mechanism is an astonishing astronomical instrument of the ancient Hellenic world. The unknown manufacturer constructed it with gears made of bronze. The construction made up of gears with carefully designed transmission ratios makes it possible to perform the computations in the rational numbers domain. The instrument probably epitomizes all the astronomical knowledge of its era. Without doubt, the Mechanism is a unique artefact in many ways –and the only device of its kind known today. It is both an astronomical instrument (Rediadis 1908) and an analogue computer (Price 1959; 1974; Theofanidis 1934) and since the day of its discovery scientists, researchers and engineers admit its priceless value (Svoronos 1903).

The Antikythera Mechanism was discovered in 1901, near the small Greek island of Antikythera, during a sponge diving (Svoronos 1903) in a large shipwreck of the 1st century B.C. that was full of ancient treasures. This intriguing and mysterious device has perplexed many scientists who have been studying it to date (Freeth *et al.* 2006; Freeth *et al.* 2008). The research studies of the Mechanism continually unveil extraordinary information about the ancient Greek science and technology, some of which was unknown and very surprising. It is an instrument whose study leads to a complete revision of the history of science, technology, astronomy, mathematics and even philosophy.



Some of the gears of the mechanism

The ancient instrument of the Mechanism has many dial displays mostly circular and two spiral, with pointers, some of which are quite complex. One dial is on the 'front' and the rest of the dials on the 'back' side of the Mechanism. The pointers are driven by gears that rotate by a single input shaft (Freeth *et al.* 2006; Freeth *et al.* 2008; Price 1959; 1974; Theofanidis 1934). The device was originally housed in a wooden case, with its manual written on every available surface of the Mechanism. It appears to have been constructed between 150 and 100 B.C. (private communication, Charis Kritzas, 2006).

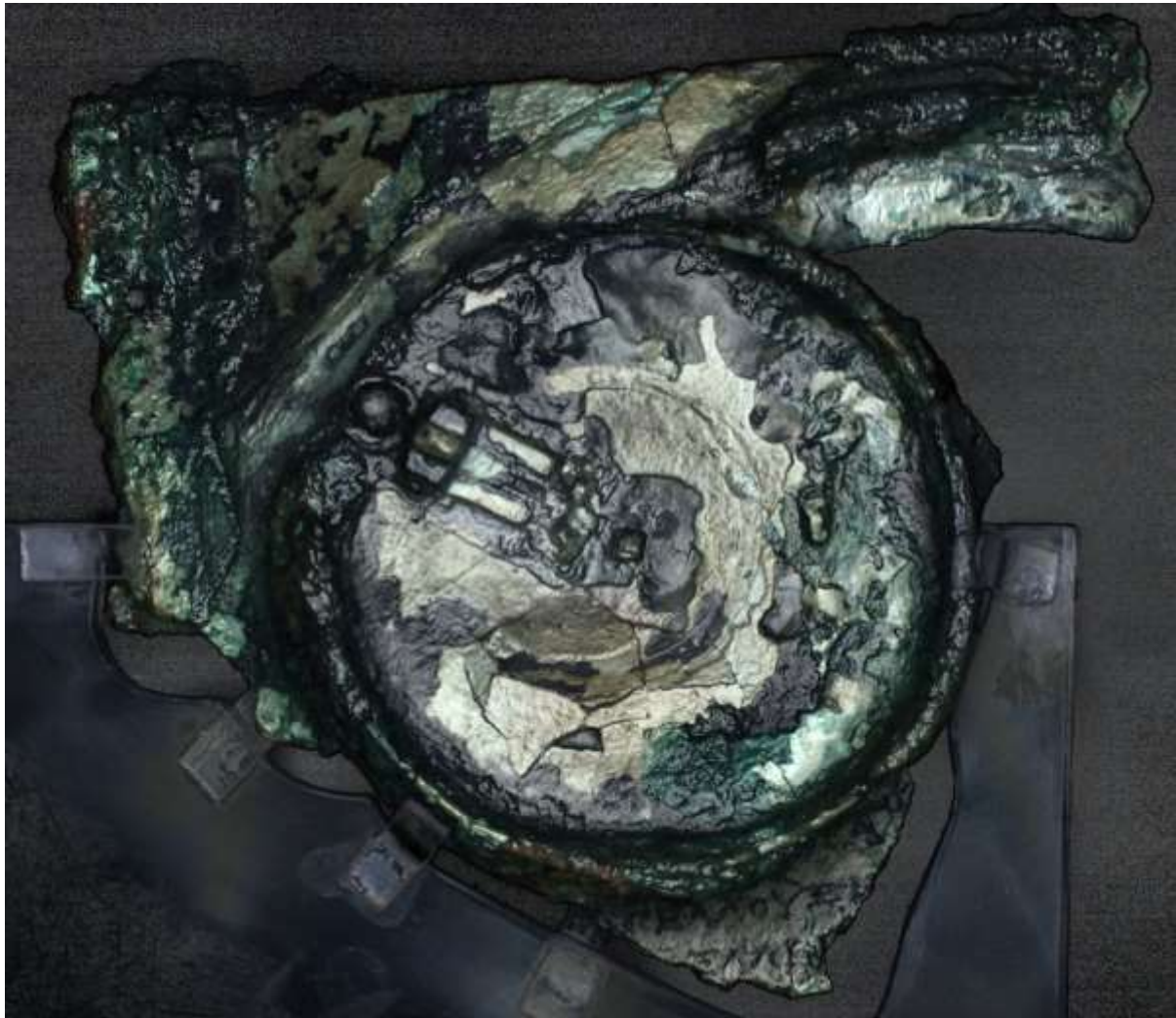
The bronze fragments of the original are on display at the National Archaeological Museum of Athens and they are being globally investigated, like other important items of astronomical instruments, such as the disk of Chevroches (Devevey *et al.* 2006).



one of our exhibitions at UNECSO, Paris.



A child in our exhibition in a Greek island



The mechanism of the moon. The moon speed follows Kepler's second law

2. The interdisciplinary value of the Antikythera Mechanism. As technology penetrates into the global community's daily routine, people find themselves in need of different types of technology applications and gadgets that they have to use every day. As a result, they need to develop special skills and acquire appropriate knowledge in order to understand the way things work and avoid the possibility of looking at them as the offspring of magic.

Despite its mysterious and complex nature, the Antikythera Mechanism is a unique educational resource and tool. It is suitable for teaching modeling of nature by using physical laws, mathematical methods and the translation of the gears' motions into mathematics. The Mechanism is the oldest known mechanical device in the human history, which proves that science can model the Universe with mathematics, astronomy and engineering.

The Mechanism is a great attractor to children for science, mathematics and technology, but also for astronomy, philosophy, history, linguistics, geography, modeling, physics, metallurgy and many more (Moussas *et al.* 2010a; Moussas *et al.* 2010b; 2010c; Moussas *et al.* 2007). Therefore, exhibitions around the world (see Table 1 below) highlighting the Mechanism, offer a tremendous opportunity for interaction between scientists and the public. For example, the Children's Museum of Manhattan (CMOM) in New York City is the only museum in America currently showcasing a reconstruction model of the Mechanism. Also, through their short audio-visual presentation, visitors from age 6 to adult, learn that it was the ancient Greek understanding of causality that led to the development of the scientific method we use today. At a nearby interactive kiosk, visitors learn how modern technology is being used to

unlock the mysteries of the Antikythera Mechanism and learn how this Greek machine is altering our understanding of the history of science.

These versatile events focus on the display of an exact replica of the Antikythera Mechanism in the same scale as the original. The reconstruction models depict the Mechanism's geared infrastructure and reveal its brilliant operation. Apart from the reconstructed device, each exhibition includes multimedia interactive software that enables the visitor to watch the history of the Mechanism as well as to investigate and understand its functions and capabilities. In addition, elucidatory panels are on display at the surrounding area, in order to involve the visitor in the roots of Science and Astronomy. During the exhibitions, public lectures concerning the amazing story of the Mechanism are given to the general public, introducing them to the ancient technology. In turn, this allows visitors of all ages to easily view the conjunction of modern science and historical heritage through the Antikythera Mechanism—and continue the conversation at home.

Most importantly, these exhibitions constitute a dynamic way for studying and learning more about astronomy, mathematics and science, revealing the interdisciplinary value of the Antikythera Mechanism.

It is obvious that the Antikythera Mechanism appears as an incredibly resourceful and educational tool for changing the way the general public views science and assists people to simplify mathematics and astronomy.

Event	Location	Date	visitors
AMERICA			
Gods, Myths and Mortals: Discover Ancient Greece Children's Museum of Manhattan	New York, USA	From 2007 to 2010	2,500,000
EUROPE			
Inauguration of the International Astronomy Year, IAU Symposium 260 and Art Exhibition	UNESCO Headquarters, Paris, France	15–23 Jan. 2009	1,000
Hellenic Physical Union, Technopolis, Gazi, Athens,	Technopolis, Gazi, Athens, Greece	1-5 Nov. 2010	1,000
Maritime Museum of Crete	Chania, Greece	Oct., Nov. 2010	2,000
European Planetary Science Conference	Angelicum Centre – Pontifical University of Saint Thomas Aquinas Rome, Italy	19 – 24 Sep. 2010,	1,000
Delphi Cultural Center	Delphi, Greece	27-31 Jul 2010	200
High School of Kythera,	Kythera, Greece	Jun. 2010	200
European Geophysical Union (EGU) 35th General Assembly	Austria Center Vienna, Austria	2-7 May 2010	2,000
High School of Skiathos	Skiathos, Greece	Feb. 2010	300
CosmoCaija/ Huygens Workshop	Barcelona, Spain	12-15 Feb. 2010	500
Museum of Science and Technology of the University of Patras	Patras, Greece	2010	1,000
Secondary Education,	Kallithea, Athens, Greece	Jan. 2010	100
Conference and Cultural Center of the University of Patras	Patras, Greece	05-08 Apr. 2009 and 2010	3,000
Secondary Education,	Kallithea, Athens, Greece	2009	400
Municipality of Salamis	Salamis, Greece	2009	300
High School of Chios, Center for Natural Studies (EKFE)	Chios, Greece	Dec. 2009	700
School <i>Hellenic Education</i>	Rhodes, Greece	Nov. 2009	600
Astronomical Institute SAS, (AISAS) Exhibition of the Antikythera Mechanism	Tatranska Lomnica, Slovakia	01 Oct.-07 Nov. 2009	351
34 th Convention of Polish Astronomical Society,	Krakow, Poland	15 Sep.-30 Oct.	350

Institute of Physics of the Jagiellonian University, Exhibition of the Antikythera Mechanism		2009	
Festival International des Sciences, Les Rencontres de la Terre	Athens, Greece	12-15 Oct. 2009	2,200
3 rd Scientific Symposium: Science and Art, Hellenic Physical Society and Harokopion University	Athens, Greece	09-11 Oct. 2009	300
6 th Hellenic Conference on Amateur Astronomy	Alexandroupolis, Greece	25-27 Sep. 2009	400
7 th General Conference of the Balkan Physical Union	Alexandroupolis, Greece	09-13 Sep. 2009	300
Olsztyn Planetarium	Olsztyn, Poland	06 May–20 Sep. 2009	10,000
International Exhibition Thessaloniki	Thessaloniki, Greece	Sep. 2009	5,000
The 13th Science Picnic of Polish Radio and the Copernicus Science Centre – The largest outdoor event in Europe promoting Science	Warsaw, Poland	30 Sep. 2009	4,000
Skiathos Cultural Center, and School of Skiathos, Greece	Skiathos, Greece	Sep. 2009	300
Museum Gustavianum Uppsala University	Uppsala, Sweden	31 Jan.–26 Apr. 2009	10,000
Culture Center City of Rethymnon	Rethymnon, Greece	27–30 Mar. 2009	300
Istituto Veneto di Scienze, Lettere ed Arti	Venice, Italy	2009	200
High School of Kranidi	Argolida, Greece	Since Mar. 2009	700
Communication with the ISS, 1 st Lyceum of Alexandroupolis - Amateur Astronomic Club of Thrace	Alexandroupolis, Greece	11 Feb. 2009	530
Ionic Center, Athens	Athens, Greece	Dec. 2008 - Jan. 2009	4,000
Exhibition of Research and Innovation, Zappeion	Athens, Greece	Nov. 2008	5,000
International Exhibition Thessaloniki	Thessaloniki, Greece	Sep. 2008	5,000
Nursery School Ermioni	Ermioni, Greece	21 Feb. 2008	60
High School, Kassos	Kassos, Greece	2008	200
Theognis Cultural Center	Megara, Greece	2010	200
Exhibition of Research and Innovation, Zappeion	Athens, Greece	Nov. 2007	5,000
AFRICA			
Averofian Greek School in Alexandria	Alexandria, Egypt	Permanent exhibition 2009	200
Planetarium Science Center Bibliotheca Alexandrina Alexploratorium	Alexandria, Egypt	Since 1 Nov. 2008	2,000
Exhibition at CRAAG, Centre de Recherche en Astronomie Astrophysique et Géophysique	Algiers Observatory, Algeria	2 Nov. 2008	50
Abet Greek School in Cairo	Cairo, Egypt	Permanent exhibition inaugurated on 29 Nov 2008	300
Exhibition in Constantine 7em Salon d'Astronomie	Constantine, Algeria	30 Oct.–1 Nov. 2008	6,000



Two gears of the four that make the lunar trajectory to follow Kepler's second law

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