Lecturer

Name: Tomasz Bulik
Background: Professor, Astrophysics
Specialization: Professor, Lecturer at Astronomical Observatory, University of Warsaw
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Lecturer

Name: Mateusz Sochacki
Background: Master of Science, Mechanics
Specialization: Assistant lecturer at Warsaw University of Technology
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Lecturer

Name: Dorota Mieczkowska
Background: Bachelor of Engineering, Applied Physics
Specialization: M. Sc. Student at Faculty of Physics, Warsaw University of Technology
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Lecturer

Name: Lukasz Mężyk
Background: Doctor, Mechanical Engineering
Specialization: Assistant Professor at Warsaw University of Technology
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Lecturer

Name: Katarzyna Kruszyńska
Name for daily/classes use: Kasia
Background: Master of Science, Astronomy
Field of Specialization: PhD student at Astronomical Observatory, University of Warsaw
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Lecturer

Name: Jakub Bochiński
Background: Doctor of Philosophy (PhD), Astronomy and Astrophysics
Field of Specialization: Head of Education at Copernicus Science Centre
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Lecturer

Name: Jędrzej Górski
Background: Master of Science, Computer Science and Engineering, Aviation Engineering
Field of Specialization: PhD Student
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Course Description

Title: The Dark Side of the Moon

Fields of activity: Aerospace/Aeronautical Engineering, Applied Sciences, Automotive Engineering, Biomedical Engineering, Chemical Engineering, Computational Sciences, Electrical/Electromechanical Engineering, Electronic/Electrotechnical Engineering, Mechanical Engineering, Mechatronics, Physics/Physics Engineering, Power Engineering, Telecommunications/Electronics, Transport Engineering

Examination type: Written Exam

Number of ECTS credits issued: 1 ECTS

Learning Goals and Objective: We are going to acquaint participants with various concepts relating to astrophysics such as black holes or gravitational waves. You will have time for discussion about life on other planets and how to search for it. We are going to expand your knowledge about orbital mechanics, rockets and space debris. At the end of the course you will be able to discuss how can you participate in this great work of humanity, which is the exploration of the universe.

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Syllabus

Name of activity	Introduction to gravitational wave astronomy 1
Number of working hours	2 hours
Type of activity	Lecture
Lecturer	Tomasz Bulik
Short summary of content	Basic physics behind gravitational waves. Estimate of the signal from a source. Binaries as sources of gravitational waves – luminosity and waveform.
Bibliography	Shapiro and Teukolsky, Black holes, white dwarfs and neutrons stars, chapter 16.
Expected effect	Introductory knowledge of gravitational wave astrophysics. Order of magnitude estimates of signals

Name of activity	Introduction to gravitational wave astronomy 2
Number of working hours	2 hours
Type of activity	Lecture
Lecturer	Tomasz Bulik
Short summary of content	Technological challenges in construction of gravitational wave detectors. Most important sources of noise. Basic ideas behind gravitational wave data analysis. The example of GW150914.
Bibliography	Abbott, B.~P., and 954 colleagues 2017.\ The basic physics of the binary black hole merger GW150914.\ Annalen der Physik 529, 1600209. https://arxiv.org/abs/1608.01940
Expected effect	Order of magnitude estimates of noise levels. Basic on to extract physical parameters from gravitational wave data.

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Name of activity	Orbital Mechanics
Number of working hours	5 hours
Type of activity	Lecture
Lecturer	M.Sc. Eng. Mateusz Sochacki
Short summary of content	• The two-body problem: equation of motion in non perturbated, spherically symmetric gravity field, Kepler's Laws, types of orbits (circular, elliptical, parabolic, hyperbolic), orbital position as function of time, orbits in three dimensions, orbital parameters; • Orbital maneuvers: impulsive maneuvers, Hohmann transfer, bi-elliptic Hohmann transfer, phasing maneuvers, apse line rotation, plane change maneuvers; • Interplanetary trajectories: sphere of influence, method of patched conics, planetary departure, planetary flyby; • Orbital perturbations: atmospheric drag, gravitational perturbations, solar radiation pressure, third bodies gravity; orbital systems: launch site considerations, ground track, orbital coverage, satellite constellations.
Bibliography	Further reading: • Curtis, Howard D. Orbital mechanics for engineering students. Butterworth-Heinemann, 2013; • Chobotov, Vladimir A. (ed.). Orbital mechanics. Aiaa, 2002;
Expected effect	The objective of the lecture is to present the main aspects of spacecraft motion. The acquired knowledge will allow to understand how the "position" of spacecraft in space is described by means of orbit, how the orbit is changed due to maneuvers and disturbances acting on a spacecraft. Students will learn how to perform preliminary calculations of interplanetary trajectories, what are the most important orbital systems and what types of orbits they use and why. The course will provide the background for the mission analysis.

Name of activity	Space debris tracking technologies
Number of working hours	2 hours
Type of activity	Lecture
Lecturer	Dorota Mieczkowska
Short summary of content	Space surveillance and tracking (SST) programmes: laser and radar techniques. Different approaches to SST. Detection and tracking of objects on orbit using Doppler-shifted signal.
Bibliography	N/A
Expected effect	Students are able to describe different methods of space debris tracking, they know the key features of SST programmes, they understand the basics of mathematical model of satellite tracking with the use of Doppler effect.

Name of activity	Satellite orbit propagation in STK Software
Number of working hours	2 hours
Type of activity	Workshop
Lecturer	Dorota Mieczkowska
Short summary of content	Basic usage of STK software. Creating satellite orbit change simulations. Simulating receiver range with various parameters. Making reports of satellite visibility to receiver in time.
Bibliography	N/A
Expected effect	At the end of the session, students will be familiar with basic usage of STK Software. They will learn how to use basic features such as orbit propagation or simulation of satellite transit in receiver range.

Name of activity	Introduction to Space Debris
Number of working hours	2 hours
Type of activity	Lecture
Lecturer	Łukasz Mężyk
Short summary of content	Definition of space debris. Sources of space debris. Are they dangerous? Why should we care? What can we do?
Bibliography	N/A
Expected effect	Students should be aware of a problem of space debris. They should be able to define space debris and explain why they are problematic. Student should be aware of different methods od space debris removal.

Name of activity	Basics of Rocket Engine
Number of working hours	4 hours
Type of activity	Lecture
Lecturer	Łukasz Mężyk
Short summary of content	Short history of rocketry, definition of rocket engine, characteristic parameters, classification of rocket engines based on energy source and functions, description of different types of rockets, examples
Bibliography	N/A
Expected effect	Students are going to gain basic knowledge about rocket engines – their principle of operation, types, basic parameters. Furthermore, students should be able to clarify the differences between types of rockets and know the most characteristic values to characterize them.

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Name of activity	Stellar Black Holes: where do they come from and how to find them?
Number of working hours	3 hours
Type of activity	Laboratory
Lecturer	Katarzyna Kruszyńska
Short summary of content	Students are going to learn about stellar evolution and what are the end products of it. They will learn about what kind of stars can produce black holes and in what environments. They will also learn on how to detect such object and what conditions have to be met to distinguish it from other objects (stars, planets). During the lecture parts students and lecturer will gather and organize accumulated knowledge. Then the students will be divided into groups (3-4 people) and given small tasks connected to the subject. These tasks will require access to a computer with scripts provided by the lecturer. It is strongly advised that the students, who wish to participate in this course, read articles listed in Bibliography. Prior knowledge from other sources is also welcome. It is required for the lecture part.
Bibliography	N/A
Expected effect	Students know and understand basics of stellar evolution, what are stellar-mass black holes and what is gravitational microlensing.

Name of activity	Planetary congress
Number of working hours	2 hours
Type of activity	Group Seminars
Lecturer	Jakub Bochiński
Short summary of content	In the sixties of the last century, the American astronomer Dr. Frank Drake proposed an equation that aimed to estimate the number of technological civilizations in our Galaxy. To calculate this number, however, he needed a lot of knowledge about planets outside the solar system. Knowledge, inaccessible at his times. With the development of technology, more and more accurate astronomical observations allow us to fill in white patches that Dr. Drake found on his way. With the discovery of 2,000 new planets, finding the answer to the question "Are we alone in the universe?" seems closer than ever before. However, we are at the crossroads. Soon we will have to make a key decision: look for quantity or quality? Look at a few intriguing planets, or browse thousands of ordinary globes in search of an oasis of life? As part of the lecture the lecturers will try to take this extremely difficult decision together.
Bibliography	N/A
Expected effect	Students will understand and know the problems, challenges and limitations that humanity faces in searching for life in the universe.

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Name of activity	Analog missions - case study of the EXO 17 analog mission in the MSRS
Number of working hours	2 hours
Type of activity	Group Seminars
Lecturer	Jędrzej Górski
Short summary of content	The EXORiON Foundation was the first organization in Poland to launch a cyclical program for testing space analogue simulations. EXO.17 took place in March 2017 in the habitat Mars Desert Research Station (MDRS) located in the desert near Hanksville, Utah in the United States. During the classes, participants will have the chance to learn how simulation missions look and run, they will also have the opportunity to discuss with the person who actually participated in this experiment.
Bibliography	N/A
Expected effect	Students understand the course and reasons for simulation missions organization.

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Name of activity	First steps in the space industry - a case study of the BEXUS / REXUS program
Number of working hours	2 hours
Type of activity	Group Seminars
Lecturer	Jędrzej Górski
Short summary of content	The REXUS/BEXUS programme allows students from universities and higher education colleges across Europe to carry out scientific and technological experiments on research rockets and balloons. During the classes, participants will discuss how to start their adventure with the space industry - what development opportunities are created by ESA and how to use them.
Bibliography	N/A
Expected effect	Students are aware of the opportunities that European organizations give them in the field of space exploration and how to use them.

Name of activity	Written Exam
Number of working hours	1 hour
Type of activity	Examination
Lecturer	Łukasz Mężyk
Short summary of content	Students will have time to complete a written test created on the basis of questions provided by the teachers regarding their classes.
Bibliography	N/A
Expected effect	Students will test their knowledge gained over whole course.

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Pre-materials

Name	Basics of space flights
Topic/field	Rocket Engines
Short description	Basic information about rocket engines, rocket propellant, together with other space related subjects.

Name	NASA site on orbital debris
Topic/field	Space Debris
Short description	Some basic information about space debris, debris mitigation, protection and many more.

Name	Wikipedia article on stellar evolution
Topic/field	Stellar Evolution

Name	What is Gravitational Lensing?
Topic/field	Gravitational Lensing

Name	Wikipedia article on gravitational microlensing
Topic/field	Gravitational Microlensing

Name	Introduction to Microlensing
Topic/field	Introduction to Microlensing

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