

ing of its numerical value. It is advisable to study the foundations of the special theory of relativity on the basic principles – the relativity and invariance of the light speed in a vacuum. During studying the material, such notion as “speed”, “time”, “length”, “impulse”, “energy” are analyzed. Students know the fundamentals of these principles and notion, it is only necessary to clarify them from the relativistic positions.

To study the material is proposed by solving problems on the calculation of the mass and length of the body, which moves at a

speed of 0.1 to 0.9 speed of light, using the graphs of the dependences  $m(v)$ ,  $l(v)$ . The proposed method clearly convinces students of the length and weight of the body from its speed relative to the speed of light. This approach activates the cognitive activity of students in the study of this topic, contributes to the formation of a scientific view and better understanding of relativistic laws.

**Key words:** teaching physics, light speed, theory of relativity, relativistic mechanics, invariance, mass, length.

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## CONTRIBUTION OF UKRAINIAN SCIENTISTS TO THE ESTABLISHMENT OF AVIATION AND ASTRONAUTICS

The contribution of Ukrainian scientists to the development of aviation and astronautics has been analyzed. The importance of the scientific works of Ukrainian scientists in the establishment of aerospace industry has been proved. The priority of Ukrainian scientists in a number of scientific issues in the world science is shown. The launch of first Sputnik, the first manned flight of man into space, the first man in the open space, the first man on the surface of Moon, the first unmanned flight of the space plane «Buran», the designing of the first aircraft with multiple motors, the first helicopter, which was made serially, and the world's largest transport aircraft «Mriia». All these achievements have been achieved thanks to works of Ukrainian scientists. Classification of the scientific works of Ukrainian scientists according to historical eras has been done. The importance of current researches in aerospace industry, which carried out by Ukrainian scientists is demonstrated.

**Key words:** aviation, astronautics, Ukrainian scientists, program «Apollo», space plane «Buran», the world's largest aircraft «Mriia», probe «Rosetta», Ukrainian rockets «Zenit» and «Cyclone-4».

*I always repeat that I am Ukrainian. This is a fundamental question for me...*

Klim Churyumov

**Formulation of the problem.** In 1991, Ukraine emerged as an independent country. A nuclear military capability of Ukraine was the third in the world [1]. It has exceeded the potentials of France, Britain and China together. In 1994, Ukraine signed Budapest memorandum under the influence of external factors. Budapest memorandum is an international agreement between Ukraine, the US, Russia and Britain about the non-nuclear status of Ukraine. According to Budapest memorandum, Ukraine became a nuclear-free state. The US, Russia and Britain have guaranteed sovereignty and territorial integrity of Ukraine. Ukraine has suffered from military aggression from Russia in 2014. War goes on. Thousands of patriots and civilians have been killed in Ukraine.

In 1991, leadership of Ukraine made the erroneous step. President and members of Parliament have not consulted with the Ukrainian people. The referendum was not held in Ukraine. One of the reasons of this false decision is a not full research of the historical past of Ukrainian people.

**An analysis of current research.** The contribution of Ukrainian scientists to the development of aviation and astronautics was demonstrated in manuals [2, 3], as well as scientific papers [4-6]. However, despite that, this issue remains challenging, because the achievements of Ukrainian scientists are substantial and demand a further analysis. The aim of this article is an analysis of Ukrainian scientists' contribution to the establishment of aviation and astronautics.

**Statement of the basic material.** For many years, Ukraine was a part of the empires (e.g., Russian Empire, Soviet Union). Soviet regime killed millions Ukrainian people. Soviet Ukraine is the world leader for the number of killed scientists, educators, artists and priests. Many Ukrainian scientists were unjustly convicted and executed. But Ukrainian scientists continued to create. The launch of first sputnik, the first manned flight of man into space, the first man in the open space, the first man on the surface of Moon, the first unmanned flight of the space plane «Buran», the designing of the first aircraft with multiple motors, the first helicopter, which was made serially, and the world's largest transport aircraft «Mriia». All these achievements have been achieved thanks to works of Ukrainian scientists.

### Ukraine in Russian empire

Oleksandr Zasiadko (1779, Poltava province – 1838, Kharkiv) was an engineer. He first created a new type of gun-

powder for rockets, several types of military missiles and a special mechanism for firing by them. Zasiadko is a constructor of multiple rocket launchers and accessories for missile guidance to the target. Rockets of Zasiadko had a flight range of 3.100 meters, and European rockets had a flight range of 2.740 meters at the same time. In 1828, Varna has been captured with using of Zasiadko's rockets during the Russo-Turkish war. Before this the siege lasted six months.

Mykola Kybalrnych (1853, Chernihiv region – 1881, Peterburg, Russia) was an author of the first world's project of space vehicle. In 1881, M. Kybalrnych took part at the preparations for the assassination of the Russian emperor Alexandr II. He has been arrested. Kybal'nych scribbled the scheme with a button on the wall of the chamber few days before death. Scientist considered the device of rocket engine, offered the flight control with using of tilting the engine, the gradual combustion of fuel, the method of stability of the space vehicle, etc. Gendarmerie seized papers and sent them to the archive. Only in 1917 the papers have been removed from the archive.

Igor Sikorsky (1889, Kyiv – 1972 Easton, United States) was an author of the first aircrafts with multiple motors («Grand», «Rus'kyi Vitiaz'» and «Iliia Muromets'»), he created the turbine helicopter, amphibious helicopter and the first helicopter, which was made serially. Sikorsky has made first experimental flight on helicopter on 14 September, 1939. After several years the helicopter S-47 has been created. Model S-47 has a big rotor and small tail rotor. At the present time almost all key production programs of the US on the construction of helicopters are based on helicopters «Sikorsky».

### Ukraine in Soviet Union

Georgii Langemak (1898, Kharkiv province – 1938, Moscow, Russia) was a constructor of missile technology, he introduced into science the term «cosmonautics», the main constructor of rocket launchers «Katyusha». This weapon was successfully used by Soviet Union during World War II. Stalin's regime condemned him to death on 11 January, 1938. He has been shot on the same day. In 1955, G. Langemak has been completely rehabilitated.

Mykola Barabashov (1894, Kharkiv – 1971, Kharkiv) was an Ukrainian astronomer. He first proved the possibility of landing of man on the Moon. Barabashov has showed that the surface of satellite has a solid structure. In 1918, he found that the Moon's surface consists of volcanic rock basalt type with a high porosity. Later it has been confirmed with direct study of the moon using of spacecraft. Barabashov has opened the polar

caps on Mars, the ice crystals at atmosphere of Venus, he has photographed the solar corona, and scientist also studied Jupiter and Saturn.

Yurii Kondratyuk, real name is Oleksandr Shargei (1897, Poltava – 1942, Kaluga region, Russia) was an author of idea of flight to the bodies of Solar system with using of the special scheme. He has developed the first known «Lunar Orbit Rendezvous», a key concept for landing and return spaceflight from Earth to the Moon [7]. Ukrainian scientist explained how to slow down the spacecraft during landing. American scientists developed a program «Apollo», based on the ideas of Ukrainian researcher. The landing of man on Moon has been completed successfully on 21 July, 1969. Kondratyuk gave the basic equations of motion missiles, he explored the structure of the jet engine and fuels for him, suggested using the gyroscope for orientation of spacecraft. In June 1931, he has been unjustly sentenced. Kondratyuk has been killed during the battle near Kaluga in 1942. He has been rehabilitated in 1970.

Sergii Korol'ov (1906, Zhytomyr – 1966, Moscow, Russia) was an Ukrainian constructor. Under the leadership of Korol'ov the first intercontinental ballistic missile has been launched (27 August, 1957), the first artificial Earth satellite has been launched (4 October, 1957), Yu. Gagarin made the first flight into space (12 April, 1961) and O. Leonenko made the first exit to open space (18 March, 1966). Ukrainian constructor has been unjustly convicted and he conducted at Stalin's camps seven years of his life. This undermined the health of scientist and was the cause of his death.

Glib Lozyno-Lozynskiy (1909, Kyiv – 2001, Moscow, Russia) was an author of jet engines for supersonic fighters «Mig», one of the founders of space complex «Energiia-Buran» (project «Spiral'»). According to project «Spiral'», space plane «Buran» launched from the surface of hypersonic aircraft, which is then returned to the airport. The successful flight of unmanned space plane «Buran» has been done on 15 November, 1988. Ukrainian scientist Arkhpy Lyul'ka (1908-1984) has proposed the engine design for «Buran». Benefits of space plane «Buran»: space plane can be used during 100 times, hypersonic aircraft carrier can be used during 1000 times; cost of launch to orbit is less than \$ 1000 per 1 kg of cargo for space plane «Buran», cost of launch is 12000-15000 \$ per 1 kg of cargo for «Space Shuttle».

Oleg Antonov (1906, Moscow province, Russia – 1984, Kyiv) was a Doctor of Engineering (1960), constructor of aircrafts, author of 30 models of gliders. From 1946 was a chief constructor of Research Design Office (today Antonov Company in Kyiv), was a general constructor of Research Design Office in 1967-1984. Oleg Antonov has signed an open letter to the Central Committee of Communist party on November 1965. This letter was a protest against political repression against intellectuals and discrimination of Ukrainian literature. Over 22,000 aircraft «Antonov» have been built. Aircrafts have been exported to over 50 countries. AN-225 «Mriia» is the most powerful, the most difficult and the world's largest plane, which rose into the air more than once. It has more than 240 world records. Space plane «Buran» has been mounted on Ukrainian aircraft AN-225 «Mriia» [8].

Mykhailo Yangel' (1911, Irkutsk region, Russia – 1971, Moscow, Russia) was a constructor of rockets, from 1954 he headed of Design Office «Pivdenne» (Dnipro, Ukraine). Yangel's grandfather has been deported with his family from Ukraine (Chernihiv province) to Russia. Mykhailo Yangel' is an author of the idea of «mortar» launch of rocket. According to this idea, rocket kept in a large container, which can be transported. It gave the opportunity to launch rocket at any point of the country. In USA scientists unleashed a similar task only after five years. Mykhailo Yangel' is an one of the main constructors of the rocket «Satan». It is the most powerful intercontinental rocket in the world. This rocket has been created in Design Office «Pivdenne» (Dnipro, Ukraine). Mykhailo Yangel' is an author of rocket «Zenit», which is used in international space program «Sea Launch».

Shain's reflector telescope was the largest telescope in Europe and the third in the world. Ukrainian astronomer Grygorii Shain (1892-1956) was an author of this telescope, but he did not live up to its creation (1960). The diameter of telescope mirror is 2.64 m. This telescope is located in Crimean Astrophysical

Observatory. The Ukrainian territory of Crimea has been illegally annexed to Russian Federation on 18 March, 2014...

### **Independent Ukraine**

Klim Churyumov (1937, Mykolaiv – 2016, Kharkiv) was an Ukrainian astronomer, Professor. The scientist known in worldwide thanks by the photographic observations of celestial bodies. In 1969, Klim Churyumov and another Ukrainian astronomer Svitlana Gerasymenko discovered comet. It was called comet Churyumov-Gerasymenko. In 1986, Klim Churyumov with Volodymyr Solodovnikov discovered comet, which was called comet Churyumov-Solodovnikov. European probe «Rosetta» has been launched into space in 2004. After 10 years, this probe successfully landed on the comet Churyumov-Gerasymenko [9]. «Rosetta» made several important discoveries [10]. In 2004, Klim Churyumov has been appointed the director of scientific and educational center Kyiv Planetarium. Scientist popularized science in Ukraine and abroad.

Yangel's Design Office «Pivdenne» (Dnipro, Ukraine) is a world leader in the use of military strategic rockets for space carriers. The rockets «Kosmos», «Interkosmos», «Cyclone-2», «Cyclone-3» launched to the Earth's orbit more than 1100 spacecraft. They played a significant role on exploration of space. The first Ukrainian satellite «Sich-1» has been launched on 31 August, 1995. «Sich 1», «Okean-O», «Sich-1M», «Mikron» (MS-1-TK), «EgyptSat-1», «Sich-2» are the Ukrainian spacecrafts, launched into orbit of Earth satellites. Environmentally friendly space rocket «Zenit» has a completely automated process of preparation and start-up. This provides highly accurate output spacecraft to orbit. There are 875 successful launches of «Zenit» at the moment. Yangel's Design Office «Pivdenne» is a member of several international space programs (e.g., «Sea Launch», «Taurus II», «Land Launch»).

In 2004, the parliaments of Ukraine and Brazil ratified agreement on long-term cooperation. According to this agreement, Ukrainian rocket «Cyclone-4» would be used in Alcantara Launch Center (Brazil). Ukrainian constructors practically have created the rocket, but Brazil terminated the agreement in April, 2015 [11]. Brazil is part of BRICS (Brazil, Russia, India, China and South Africa). In this way, politics is the reason of termination of cooperation.

Today Ukrainian scientists are in talks about using of rockets «Cyclone-4» in the North America [12]. Successful launch of rocket «Antares OA5» has been held in Virginia (USA) on 18 October, 2016 [13]. Yangel's Design Office «Pivdenne» has created the first stage of this rocket. Ukrainian Companies «Pivdenmash» (Dnipro), «Hartron-ARKOS» (Kharkiv), «Hartron-Yukom» (Zaporizhia), «Chezara» and «Rapid» (Chernihiv) also took part in creation [14].

In 2011, the first and only currently astronaut of independent Ukraine Leonid Kadeniuk in interview to BBC said: «Ukraine is among of six states in the world, which have the complete cycle of space technology production...» [15]. In the same interview he said that space technology in USA provides \$ 14 profit by invested 1 \$.

Many Ukrainian scientists are regarded to be Russian (e.g., Zasiadko, Kybal'chych), Soviet (e.g., Langemak, Korol'ov) or American (e.g., Sikorsky). This is not only in Russia. English edition wrote: «Astronauts Tom Stafford, John Young and Gene Cernan were about to test out a technique for lunar landing which had first been proposed in 1916 by a Russian mechanic called Yuri Kondratyuk» [16].

We have showed that familiarization with activities of Ukrainian scientists enables to implement the national component in physics teaching [17, 18]. This provides the patriotic education of youth. Highlighting of contribution of scientists of certain national to science in any case should not cause of national strife. The main principle: science should unite, but not divide peoples, and be the foundation of peace in the world.

**Conclusions.** Stalinist regime unjustly sentenced the many Ukrainian scientists (e.g., Valentyn Glushko (1908-1989), an author of the world's first rocket engine on liquid fuel). Others scientists have been shot (e.g., Kostiantyn Kalinin (1889-1938), an author of the prototype of modern supersonic aircraft). But

all they worked in spite of everything. Ukrainian scientist Ivan Puliui said: «There is no greater honour for an intelligent person than to protect his own and national honour and to work for his people's good to secure them a better fate without any reward».

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### ВНЕСОК УКРАЇНСЬКИХ ВЧЕНИХ У СТАНОВЛЕННЯ АВІАЦІЇ ТА КОСМОНАВТИКИ

Проаналізовано внесок українських вчених у розвиток авіації, космонавтики та астрономії. Доведено важливість робіт українських вчених у становленні авіакосмічної галузі. Висвітлено пріоритетність у світі низки робіт, які виконані українськими вченими. Запуск першого штучного супутника Землі, перший політ людини у космос, перший вихід людини у відкритий космос та на поверхню Місяця, перший безпілотний політ космічного літака «Буран», конструювання перших багатомоторних літаків, перших гелікоптерів, які розпочали виробляти серійно, та найбільшого у світі транспортного літака «Мрія», – усі ці здобутки людства в авіакосмічній галузі досягнуто саме завдяки роботам вчених України. Проведено класифікацію робіт українських вчених згідно з історичними епохами. Показано актуальність робіт, які виконуються українськими вченими на даний час у авіакосмічній галузі.

**Ключові слова:** авіація, космонавтика, українські вчені, програма «Аполлон», космічний літак «Буран», найбільший в світі літак «Мрія», зонд «Розетта», українські ракети «Зеніт» і «Циклон-4».

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### ВКЛАД УКРАЇНСЬКИХ УЧЕНИХ У СТАНОВЛЕННЯ АВІАЦІЇ І КОСМОНАВТИКИ

Проанализирован вклад украинских ученых в развитие авиации, космонавтики и астрономии. Доказана важность работ украинских ученых в становлении авиакосмической отрасли. Освещено приоритетность в мире ряда работ, выполненных украинскими учеными. Запуск первого искусственного спутника Земли, первый полет человека в космос, первый выход человека в открытый космос и на поверхность Луны, первый беспилотный полет космического самолета «Буран», конструирование первых многомоторных самолетов, первых вертолетов, которые начали производить серийно, и крупнейшего в мире транспортного самолета «Мрия», – все эти достижения человечества в авиакосмической отрасли достигнуто именно благодаря работам ученых Украины. Показано актуальность работ, выполняемых украинскими учеными в настоящее время в авиакосмической отрасли.

**Ключевые слова:** авиация, космонавтика, украинские ученые, программа «Аполлон», космический самолет «Буран», крупнейший в мире самолет «Мрия», зонд «Розетта», украинские ракеты «Зенит» и «Циклон-4».

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