



Country BULGARIA	Institution Vasil Levski National Military University	Module Ballistics	ECTS 5.0
Service All Languages English, Bulgarian	Minimum Qualification for Lecturers <ul style="list-style-type: none"> • English: Common European Framework of Reference for Languages (CEFR) Level B2 or NATO STANAG 6001 Level 2. • Adequate physical training and medical condition. • Adequate pedagogical and psychological competences. • Thorough knowledge of the topic taught. 		
Prerequisites for international participants: <ul style="list-style-type: none"> • English: Common European Framework of Reference for Languages (CEFR) Level B1 or NATO STANAG Level 2. • The end of the 3 th year of national (military) higher education. • Preliminary theoretical knowledge in mathematics, mechanics, thermodynamics, gas dynamics and gunpowder. 		Goal of the Module: <ul style="list-style-type: none"> • Defining the basic concepts and definitions in the field of inner, outer and final ballistics. • Fundamental knowledge about physicochemical, thermodynamic and mechanical processes in the tube of gun barrel due to the shot. • Fundamental knowledge about motion of the projectile in the air under the influence of gravity and air resistance. • Presentation the main tasks and contents that are solved by the internal and external ballistics in the design and operation of the rocjets, small arms and artillery armament. • Analyzing the impact of the parameters of the internal, outer and final ballistics. • Presentation main directions for development and improvement of the ballistics of the various ammunition for rocket launchers, small arms and artillery armament. 	

Learning outcomes	Know-ledge <ul style="list-style-type: none"> • The phases of gunpowder combustion mechanisms and pressure dependence and charging conditions. • Knowledge of ongoing processes as a result of the shot phenomenon in the barrel. • Studying the methods of solving the fundamental tasks of internal ballistics for small arms and artillery armament. • Basic knowledge for ballistic design of a gun barrel of small arms and artillery armament. • Basic knowledge of aerodynamic forces and moments acting on shells and unmanageable rockets when they moves out of the cannon or rocket launchers. • Basic knowledge of methods of calculating trajectories and studying the oscillatory movement of projectiles and unmanageable rockets relative to the center of the mass.
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	Skills	<ul style="list-style-type: none"> • Define the mechanisms of gunpowder combustion and the relationship between pressure and charging conditions. • To be able to determine the pressure during the firing phenomenon in the gun barrel. • To be able to determine the temperature during the firing phenomenon in the gun barrel. • To be able to determine the velocity of the projectile in the gun barrel. • Formulating the reversal task of internal ballistics and being able to perform a ballistic design of a gun barrel. • Skills to solve the system of aerodynamic forces that act on the projectiles and unmanageable rockets during the flight. • Skills to calculating the trajectories and the oscillatory motion of the projectiles and unmanageable rockets relative to the center of the mass.
	Competences	<ul style="list-style-type: none"> • Capacity to calculate and analyze the burning parameters of the gunpowder in closed volume s. • Capacity to demonstrate the ability to derive the basic equation of the internal and external ballistic. • Capacity to explain the nature of the gas-dynamic processes that occur as a result of the shot and to demonstrate the skills to solve the fundamental task of internal and external ballistics. • Capacity to demonstrate skills for ballistic design of a guns tube and explain the peculiarities of internal and external ballistics of special types of artillery systems. • Capacity of explaining the forces and moments acting on unmanageable rockets and projectiles and demonstrating knowledge of the methods of calculating the active and passive trajectories. • Capacity of demonstrate knowledge of the impact of unmanageable rocket and projectile fluctuations on the center of mass trajectory and the impact of the change in firing conditions on the flight path of non-steered rockets and projectiles and the methods for determining corrections.

<p>Verification of learning outcomes</p> <ul style="list-style-type: none"> • Observation: Throughout the Module students are to accomplish different practical tasks and a research project. The Module has three topics. During these tasks and a research project students are to be evaluated to verify their competences. • Test: At the end each topic of the Module the students have to accomplish specific practical tasks. • Project: At the end of the Module the students present their projects and answer questions.

Module Details		
Main Topic	Recommended WH	Details
Topic I		
Internal Ballistics	30	The theoretical and applied aspects are studied the mechanisms of gunpowder combustion and the dependence between the combustion parameters, the shot phenomenon and the basic equation of the internal ballistics, the advancing movement of the projectile and the gas-dynamical



Erasmus Course
Ballistics
Description

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		processes flowing into the gun tube.
Topic II		
Exterior Ballistics	30	To study in theoretical and applied aspects the forces and moments that act on unmanageable rockets and projectiles; methods for calculating the active and passive trajectories; the influence of unmanageable rockets and projectiles on the trajectory of the center of the table; the impact of the change in firing (launch) conditions on the flight path of unmanageable rockets and projectiles and the methods for determining corrections; scattering of unmanageable rockets and projectiles; the basics of compilation methods Artillery Shooting Tables and ball rate measures in ballistic shooting preparation.
Topic III		
Project		Solving the main task of Inner Ballistics and the main task of External Ballistics for a specific artillery system.
Additional hours to increase the learning outcomes		
Self-Study		<ul style="list-style-type: none">• Enhancing knowledge by studying specific documents.• Reflection of the topics issued.
Total	60	

This “Ballistics” study course description is created and revised at “Weapons and Design Technologies” Department and accepted at Faculty council.

Developed by: prof. Krasimir Kalev, PhD

REFERENCES:

1. Serebryakov. M. E. Interior Ballistics of Bore Systems and Solid Fuel Rockets. ASIN: B00B65UMLA. 1974.
2. Donald E. Carlucci, Sidney S. Jacobson Ballistics: Theory and Design of Guns and Ammunition. ISBN-10: 113805531X. 2018.
2. Kalev K. G. Analytical determination of pressure in the gun barrel taking into account the wear. MTA. Bucharest. 2015.
3. Kalev K. G. One approach for studying the cannon barrel wall heat transfer. MTA. Bucharest. 2016.