

# Elements of Exterior Ballistics

LONG RANGE SHOOTING

FIRST EDITION

GEORGE KLIMI

# Elements of Exterior Ballistics

LONG RANGE SHOOTING

FIRST EDITION

GEORGE KLIMI

Copyright © 2016 by George Klimi.

Library of Congress                      2016902024  
Control Number:

ISBN:	Hardcover	978-1-5144-5767-2
	Softcover	978-1-5144-5766-5
	eBook	978-1-5144-5765-8

All rights reserved. No part of this book may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the copyright owner.

Any people depicted in stock imagery provided by Thinkstock are models, and such images are being used for illustrative purposes only.  
Certain stock imagery © Thinkstock.

Rev. date: 03/07/2016

Xlibris  
1-888-795-4274  
[www.Xlibris.com](http://www.Xlibris.com)  
730788

# Contents

Author

Acknowledgment

Preface

Short Description

## **Chapter 1**

A Brief Approach to Aiming with Small Arms

Introduction

1.1 Projectile Ballistic Trajectory

1.2 Ballistic Trajectory, Bullet Drop and Departure Angle

1.3 Trajectory Height above the Horizontal Line

1.4 Aiming Angle, Angle of Sight-Scope and Departure Angle

1.5. Change of Zero Range

1.6 Testing and Adjusting Aiming Angle

1.7 Coordinate System Associated with Line of Sight

1.8 Height of Trajectory over Line of Sight

1.9 Change of Zero Range Using Bullet Path

1.10 Change of Zero Range Using Trajectory Height

1.11 Trajectory Height and Bullet Path Tables

## **Chapter 2**

Long Range Inclined Shooting

Introduction

2.1 A Practical Method on Inclined Shooting

2.2 Basic Formula for Inclined Shooting

2.3 Drop, Super Elevation Angle and Inclined Range

2.4 Rigidity Principle of Projectile Trajectory

2.5 Non-Rigidity Principle of Trajectory

2.6 Shooting with Departure Angle Zero



2.7. Numerical and Approximate Solutions

2.8 Exterior Ballistics PC Programs

### **Chapter 3**

Standard Atmosphere in Exterior Ballistics

Introduction

3.1 Standard Atmosphere

3.2 Characteristics of Atmospheric Air

3.3 Change of Air Characteristics with Altitude

3.4 Barometric Formula

### **Chapter 4**

Elementary Exterior Ballistics

Introduction

4.1 Modified Piton-Bressant Trajectory

4.2 Exponential Equation of Projectile Trajectory

4.3 Exponential Equation in Non-Standard Atmosphere

4.4 Modified Exponential Equation of Trajectory

4.5 Effect of Cartridge Temperature on Projectile Trajectory

4.6 Approximate Equations to Estimate the Coriolis Effect

4.7 Determination of Coriolis Effect, Spin Drift and Wind Effect

4.8 Range-Wind and Cross-Wind

4.9 Newton-Snell's Law in Exterior Ballistics

4.10 Tangent Law on Similar Trajectories

### **Chapter 5**

Differential Equations of Exterior Ballistics

5.1 Differential Equations of Projectile Trajectory

5.2 Reference G-Functions of Resistance

5.3 Characteristic G-functions of Resistance

5.4 Characteristic G-function Versus Reference G-function

5.5 Estimation of Coriolis Effect

5.6 Lift Force and Overturning Moment on Spinning Projectile

5.7 Gyroscopic Stability Factor and Twist rate

5.8 Estimation of Projectile Spin Deflection

5.9 Improved Euler's Method Applied in Exterior Ballistics

5.10 Measurement of Muzzle Velocity

Appendix A–Reference G-functions of Resistance

Appendix B–Characteristic G-functions

Appendix C–PC Programs

Appendix D–PC Programs

Appendix E–PC Programs

Appendix F–Algorithm of Improved Euler's Method Applied to  
Predict the Projectile Trajectory

Appendix G–Excel program on IEM

Appendix H–Electronic Copies of PC Programs

Disclaimer

References

End Notes

# AUTHOR

George Klimi (Gjergj Klimi), Ph.D., is a retired associate professor of Mathematics who taught Math at NYC College of Technology and at Pace University (New York).

George is the author of four books on exterior ballistics: "Exterior Ballistics with Applications" (2008), "Exterior Ballistics of Small Arms" (2009), Exterior Ballistics: A New Approach (2010), Exterior Ballistics: The Remarkable Methods (2014)

The third edition of "Exterior Ballistics with Applications", Xlibris, is published in December 2011.

George Klimi, from 1970 until 1993, has been professor of Physics & Mathematics and chair of Physics Department at the Military Academy of Tirana, Albania.

In 90's George used to work at the Committee of Science and Technology, and at the Ministry of Higher Education and Research in Albania as Director of TEMPUS Office, responsible for the implementation of the European Community Programs to restructure the higher education.

He was awarded the Gold Medal of Eagle, by the President of Republic of Albania, for his contribution in the democratic movement against dictatorship, and for restructuring the higher education in Albania.