SUBJECT	FORENSIC SCIENCE
Paper No. and Title	Paper No. 6: Forensic Ballistics
Module No. and Title	Module No.16: External ballistics - IV
Module Tag	FSC_P6_M16

Principal Investigator	Co-Principal Investigator	Co- Principal Investigator (Technical)
Prof. (Dr.) A.K. Gupta Professor and Head, Department of Forensic Science Ex-Head, Department of Chemistry Sam Higginbottom Institute of Agriculture, Technology &Sciences	**Dr. G.S. Sodhi** Associate Professor Forensic Science Unit Department of Chemistry SGTB Khalsa College University of Delhi	**Dr. (Mrs.) Vimal Rarh** Deputy Director, Centre for e-Learning and Assistant Professor, Department of Chemistry, SGTB Khalsa College, University of Delhi *Specialized in : e-Learning and Educational Technologies*
Paper Coordinator	**Author**	**Reviewer**
V. N. Sehgal Ex- Director CBI, Central Forensic Science Laboratory, Head of the Department & ex Officio Chemical Examiner to Govt. of India	**V. N. Sehgal** Ex- Director CBI, Central Forensic Science Laboratory, Head of the Department & ex Officio Chemical Examiner to Govt. of India	**Dr. J. K. Modi** Retd. Scientist, Forensic Science Lab, Agra, U.P.
Anchor Institute : SGTB Khalsa College, University of Delhi		

TABLE OF CONTENTS

1. Learning Outcomes

After studying this module, you shall be able to

- Know about Yaw and Stability of bullet
- Identify the effects of projectile on bullet trajectory
- Learn about the Firing angle

2. Introduction

External ballistic has assumed great importance because of its application especially in space travel. It has tremendous use in India where criminals for the commission of murder/homicide and other crimes are using a large number of illegal homemade guns. External ballistics starts where the internal ballistic ends. Internal ballistics makes study of what happens inside the barrel of the gun till the projectiles/bullet leaves the muzzle whereas external ballistics is involved in the spread of pellets in a shot gun, trajectories of bullets etc.

3. Angle of Firing

The angle of fire is the angle at which the barrel axis lines with the base line. When the angle of elevation/firing (measured in minutes) is one minute, then the line of fire and base line will get apart by a distance of over one millimeter at four meters and about 30 centimeters at one thousand meters. The angle of elevation is generally low. Especially in cases of hunting purposes these angles can have lower values and this also holds good for normal cases as well. However if the target animal is at a higher point, the position may be different.

With small arms bullet, maximum range is attained at an elevation of about 29^0. From $_{29}{}^0$ to $_{35}{}^0$, there is little increase in range. The angle of elevation at which maximum range is attained is called as the critical angle. There is no accurate way of determining the maximum range of a bullet. The use of ballistic table or ballistics software based on the slacci/mayevsri G-I drag model is considered the most appropriate method for general use. There is an additional modern alternative also available, presented by profess Arthur J Paisa in 1991.

When the firing is at an angle, the elevation may give rise to an area which may be called a safe zone along the trajectory because the projectile will be moving over the heads of the persons standing along the base line. If a .303" rifle is fired when the sights are set to a target range of less than 300 meters there would be practically no safe zone throughout the entire range. At greater ranges, however, there will be safe zones. Safe zones are determined with the help of a graph. The heights of the trajectory at various distances for the given elevation are plotted against the distance. The absolutely safe zone for the given elevation is the portion of the trajectory where the height is over and above the height of the target, two meters from the ground in the case of a human target. There is no difficulty in finding the safety zone limits and exercise of finding them is quite easy.

4. Yaw and Stability

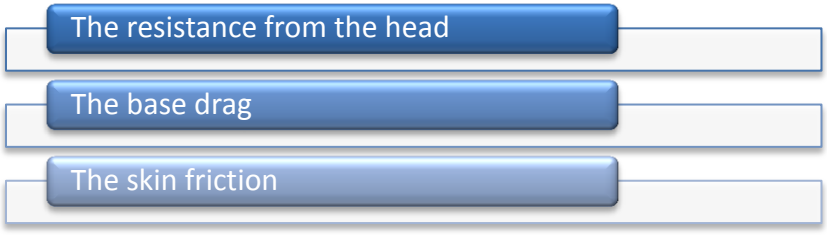
Yaw is something, which only has real relevance to rifled ammunition. This is due to slight destabilization of the bullet as it leaves the barrel and is probably the result of excessive spin on the bullet. This causes the bullet to describe an air spiral while at the same line having a spin around its own tail axis.

Fig 1: Showing Yaw Effect

At close ranges, this results in large target group than would be expected. As the range becomes greater the effect disappears and the target groups return to their normal expected dimensions. The effect is very similar to the spinning top, which wobbles slightly before settling down into a stable, spinning condition. In other words, yaw is over stabilization of the bullet as it leaves the muzzle resulting in the bullet describing an air spiral which at the same time spins round its own tail axis.

5. Effect of Projectile on trajectory

Trajectory of a projectile gets affected with the shape of the bullet because different shapes of the bullet face different air resistances. Some overcome air resistance better than others. A projectile suffers setback to its movement from many factors, some of them are mentioned below:



So far as the skin resistance is concerned, it occurs due to the interaction of air and the metal molecule, but its magnitude is very small and is to be considered negligible.

As far as base drag is concerned, it results from the backward sucking of the projectile due to vacuum created by it, when it moves forward. The forward movement of the bullet creates vacuum and hence a base drag. When the projectile is given a shape as boat-tailed, the base drag gets considerably reduced.

The head resistance is the most significant of all the factors. The head resistance force is a force, which acts on a moving body or projectile. Since this retarding force depends on the head area called as the projection area, that becomes more when head area is more and less when the head area is less. As head resistance is directly proportional to the projection area / head area. It has resulted in great popularity of users. These are called SPITZER bullets. To measure the efficiency of the shape of a bullet so as to overcome air resistance, it is done in terms of FORM FACTOR or coefficient of reduction, which can be determined experimentally by comparing the retardation of the projectile under investigation with standard projectile or utilizing other methods.

Apart from shape, there is another important factor requiring consideration and that is uniformity of the projectile structure. It is therefore absolutely essential that center of shape must coincide with the center of gravity to avoid oscillation of the bullet during the flight as well as irregular trajectories. If this condition is not met, the trajectory will become irregular and will strike at a point away from the defined point on the target.

Non-uniformity can result due to non-uniformity of jacket of the bullet or improper molding of the lead case or presence of bubbles in the projectile. The air resistance will affect the trajectory of a bullet/projectile by reducing its velocity and by pushing it in the direction it is blowing. The resistance of air depends on its density as well as temperature. Thinner the air, the lesser will be the air resistance. Higher temperatures of atmosphere tend to decrease the air resistance.

6. Drift

Drift is caused by the action of wind that not only tries to hold the bullet back but also alters the direction of the spin. Gyroscopic drift therefore may be defined as the gradual deviation of a bullet from its intended path due to its spinning motion imparted by the rifling of the barrel. A bullet fired by a rifled weapon having rifling to the right has the tendency or drift to the right and left-handed rifling will result in left – handed drift. Drift becomes very pronounced at long ranges. The drift of a 0.0306 bullet at a range of 2000 yards has been found to be 12.5 feet. At short ranges, drift is very small it is about one foot for the same bullet at 1000 yards. It may be interesting to note that most rifles have some lateral jump (angular displacement) during firing whose estimation is quite difficult.

7. Summary

- Drift is caused by the action of wind that not only tries to hold the bullet back but also alters the direction of the spin.
- Yawing is caused due to slight destabilization of the bullet as it leaves the barrel and is probably the result of excessive spin on the bullet.
- The angle of fire is the angle at which the barrel axis line with the base line.
- The air resistance will affect the trajectory of a bullet/projectile by reducing its velocity and by pushing it in the direction it is blowing.
- When the firing is at an angle, the elevation may give rise to an area, which may be called as safe zone along the trajectory.