FM 3-04.203

Fundamentals of Flight

May 2007

Headquarters, Department of the Army

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Field Manual
FM 3-04.203

Headquarters
Department of the Army
Washington, D.C. 7 May 2007

Fundamentals of Flight

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***This publication supersedes FM 1-202, 23 February 1983; FM 1-203, 03 October 1988; TC 1-201, 20 January 1984; and TC 1-204, 27 December 1988.**

Figures

Tables

Preface

Field manual (FM) 3-04.203 still presents information to plan and conduct common aviation tasks for fixed- and rotary-wing flight. However, it has become more inclusive and its scope broadened to reduce the number of manuals used by Army crewmembers for reference

One of the underlying premises of Army aviation is if crewmembers understand 'why' they will be better prepared to 'do' when confronted with the unexpected. FM 3-04.203 endeavors to ensure that crewmembers understand the basic physics of flight, and the dynamics associated with fixed- and rotary-wing aircraft. A comprehensive understanding of these principles will better prepare a crewmember for flight, transition training, and tactical flight operations.

Because the U.S. Army prepares its Soldiers to operate anywhere in the world, this publication describes the unique requirements and flying techniques crewmembers will use to successfully operate in extreme environments, not always encountered in home station training.

As a full-time force, the U.S. Army is capable of using the advantages of its superior night operation technologies to leverage combat power. To that end, Army crewmembers must be familiar and capable of performing their mission proficiently and tactically at night. The information on night vision systems (NVSs) and night operations in this circular will provide the basis for acquiring these skills.

Every aviator understands that the primary purpose is to operate aircraft safely. Every crewmember must perform the mission effectively and decisively in tactical and combat operations. FM 3-04.203 also covers basic tactical flight profiles, formation flight, and air combat maneuvers.

FM 3-04.203 is an excellent reference for Army crewmembers; however, it can not be expected that this circular is all inclusive or a full comprehension of the information will be obtained by simply reading the text. A firm understanding will begin to occur as crewmembers become more experienced in their particular aircraft, study the tactics, techniques, and procedures (TTP) of their units, and study other sources of information. Crewmembers honing skills should review FM 3-04.203 periodically to gain new insights.

This publication applies to the Active Army, the Army National Guard/Army National Guard of the United States, and the United States Army Reserve unless otherwise stated.

The proponent of this publication is Headquarters, United States Army Training and Doctrine Command (TRADOC). Send comments and recommendations on Department of the Army (DA) Form 2028 (Recommended Changes to publications and Blank Forms) or automated link (http://www.usapa.army.mil/da2028/daform2028.asp) to Commander, U.S. Army Aviation Warfighting Center ATTN: ATZQ-TD-D, Fort Rucker, Alabama 36362-5263. Comments may be e-mailed to the Directorate of Training and Doctrine at av.doctrine@us.army.mil. Other doctrinal information can be found on the Internet at Army Knowledge Online (AKO) or call defense switch network (DSN) 558-3551 or (334) 255-3551.

Unless this publication states otherwise, masculine nouns and pronouns do not refer exclusively to men.

This publication has been reviewed for operations security considerations.

Chapter 1

Theory of Flight

This chapter presents aerodynamic fundamentals and principles of rotary-wing flight. The content relates to flight operations and performance of normal mission flight tasks. It covers theory and application of aerodynamics for the aviator, whether in flight training or general flight operations. Chapter 7 presents additional information on fixed-wing (FW) flight.

SECTION I – PHYSICAL LAWS AND PRINCIPLES OF AIRFLOW

NEWTON'S LAWS OF MOTION

1-1. Newton's three laws of motion are inertia, acceleration, and action/reaction. These laws apply to flight of any aircraft. A working knowledge of the laws and their applications will assist in understanding aerodynamic principles discussed in this chapter. Interaction between the laws of motion and aircraft mechanical actions causes the aircraft to fly and allows aviators to control such flight.

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INERTIA

1-2. A body at rest will remain at rest, and a body in motion will remain in motion at the same speed and in the same direction unless acted upon by an external force. Nothing starts or stops without an outside force to bring about or prevent motion. Inertia is a body's resistance to a change in its state of motion.

ACCELERATION

1-3. The force required to produce a change in motion of a body is directly proportional to its mass and rate of change in its velocity. Acceleration refers to an increase or decrease—often called deceleration—in velocity. Acceleration is a change in magnitude or direction of the velocity vector with respect to time. Velocity refers to direction and rate of linear motion of an object.

ACTION/REACTION

1-4. For every action, there is an equal and opposite reaction. When an interaction occurs between two bodies, equal forces in opposite directions are imparted to each body.

FLUID FLOW

BERNOULLI'S PRINCIPLE

1-5. This principle describes the relationship between internal fluid pressure and fluid velocity. It is a statement of the law of conservation of energy and helps explain why an airfoil develops an aerodynamic force. The concept of conservation of energy states energy cannot be created or destroyed and the amount of energy entering a system must also exit. A simple tube with a constricted portion near the center of its length illustrates this principle. An example is using water through a garden hose (figure 1-1). The mass of flow per unit area (cross sectional area of tube) is the mass flow rate. In figure 1-1, the flow into the tube is constant, neither accelerating nor decelerating; thus, the mass flow rate through the tube must be the same at stations 1, 2, or 3. If the cross sectional area at any one of these stations—or any given point—in the tube is reduced, the fluid velocity must increase to maintain a constant mass flow rate to move the same amount of fluid through a smaller area. Fluid speeds up in direct proportion to the reduction in area. Venturi effect is the term used to describe this phenomenon. Figure 1-2 illustrates what happens to mass flow rate in the constricted tube as the dimensions of the tube change.

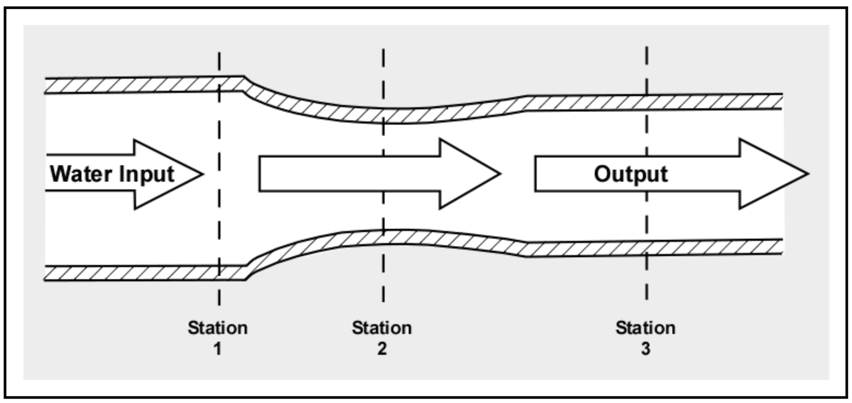

Figure 1-1. Water flow through a tube

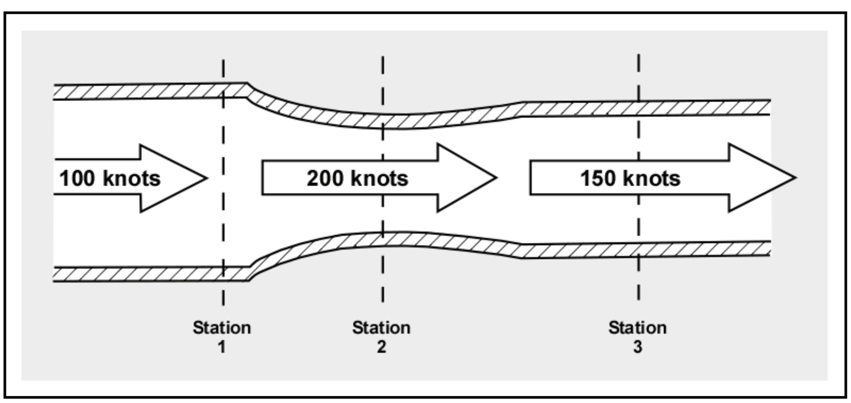

Figure 1-2. Venturi effect

VENTURI FLOW

1-6. While the amount of total energy within a closed system (the tube) does not change, the form of the energy may be altered. Pressure of flowing air may be compared to energy in that the total pressure of