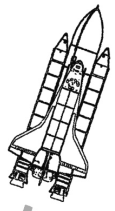
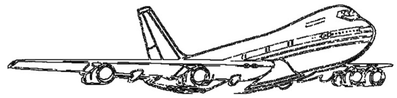
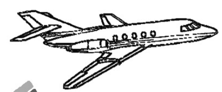


APPLIED AVIATION PHYSIOLOGY





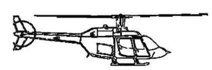


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TABLE OF CONTENTS

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ILLUSTRATIONS

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TABLES

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CHAPTER

I

Basic Science Review

Natural Laws and Theories

AVIATION PHYSIOLOGY HISTORY

A brief review of man in flight reveals that man discovered how quickly flight overcame his very limited physical abilities. It is remarkable how quickly humans developed methods of combating their aviation vulnerabilities. There is a plethora of scholarly works on aviation history and aviation medical advances, so we will not attempt to duplicate those fine works. Perhaps a short review of the highlights of modern aviation physiological history will illustrate how far we have come in a very short period of time.

Mankind has always admired the ability of the birds of the air to move quickly from place to place in the atmosphere. Undoubtedly, prehistoric man envied such ability, and he must have studied birds from the very beginning of his time here on earth, and legends grew up around real and imagined flight. From China to Western Europe to the plains of what would become America, mythical figures could "fly." The Ancient Greeks made such flying creatures "gods" and some societies created legendary combination creatures such as serpents, horses and wild animals that could fly. Thus we have "Dragons" and the "Pegasus" as well as humans with feathers and wings.

However, as the scientific study methods and the industrial age began to overtake legends, serious studies began to be made of flight and its effects on humans. Leonardo da Vinci explored the concept of a helicopter, gliders, the parachute and multiple other flight ideas. It wasn't long before balloons found their way from the "experimental hobby" phase beginning as early as the 14th century to the "operational stage" of the 18th century. ***Joseph Montgolfier*** and his brother, Etienne Montgolfier, started with small hot air balloons but progressed to giant balloons that could carry several individuals a short distance.

Montgolfier

Other French scientists and engineers soon followed with ***J.A.C. Charles*** and ***Pilatre de Rozier*** constructing more sophisticated balloons, some using hydrogen, which could travel higher and had greater carrying capacity. Charles, being a scientist, noted the cold temperatures at altitude, and complained of aching ears, and the chronicling of the physiological effects of flight had begun. Deaths from exceeding human flight physiological limits soon began.

Charles

Rozier

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Dr. Rush

Dr. Bert

Dr. Benjamin Rush took medical data from the balloon adventurers of the day, and the field of Aviation Medicine was born. Within a few short years, observations of increased cardiac activity, frostbite, and visual disturbances were recorded, and two Englishmen nearly died of what we now know was hypoxia in the 1860s. By the late 1860s, ***Dr. Paul Bert*** published scholarly papers on reduced atmospheric pressures and experimental physiology and even built the first crude altitude chamber to conduct experiments on flight personnel. Dr. Bert is generally considered to be the first true flight surgeon.

Lt. Selfridge

Wright Brothers

Of course, we know that flight history accelerated quickly after the balloon and glider eras, and, eventually, powered flight was achieved. However, man's physiological problems were just beginning. The tragic death of ***Lt. Selfridge,*** a passenger in a flight conducted by one of the ***Wright Brothers,*** spurred the medical community to insist on head protection for flyers. This admonition quickly leads to other physical and physiological requirements for flight, and the U.S. Army and U.S. Navy issued detailed physical guidelines for all flyers.

The advent of World War I spurred the development of aircraft with advanced capabilities, and it quickly became apparent that humans were no match for the machinery. As a result, intensive research began on how to protect aviators in flight, and special personal equipment, cockpit designs, parachutes, goggles, helmets, gloves, jackets and boots were developed. As speed and altitudes increased, the need for oxygen became imperative, so oxygen systems began development. By the time World War II began, the need for pressurization was recognized, and the problems of disorientation were finally being addressed in a scientific manner. Instruments were developed and training began to emphasize the limitations of our eyes, vestibular and body sensor systems. Modern aviation physiology had begun in earnest, and the military was in the forefront of the research effort.

So, what have we learned, and where are we going in this man-machine relationship? Lets take a look…………………..

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TOOLS FOR EXPLORING THE OCEAN OF GAS

BASIC SCIENCE REVIEW

Atmosphere

Before we can explore the ***atmospheric*** ocean, we must first understand some basic scientific information. Of course, any time we start studying the world around us, and especially gases, we have to know something about measurements, distances, structures, movement, and composition of materials, heat and the natural laws governing activity. Perhaps our exploration should begin with a review of some of those concepts.

Introduction to Measuring Things

Most of us would be very pleased if all measurements were in the metric system. Most of the world uses the metric system, and it makes measuring and calculating values extremely simple. Unfortunately, several countries, including the United States, just can not seem to break away from the traditional English measurement system, and that presents a serious problem to citizens of almost all countries. However, since most pilots and aviation professionals will have to work with, or fly in, the U.S. aviation system, it is essential that everyone in the industry clearly understand the measurement systems used in North America. It certainly is not fair that the rest of the word must learn the U.S. system of measurement, but until the U.S. is able to change, or until the U.S. is no longer the dominant aviation system in the world, it is necessary. Safe flight demands that everyone understand the measurement systems used in transmitting essential information, even if it is not fair.

Measurement Systems

Measurement Systems

Historically, aviation incorporated a variety of ***measurement systems*** as the technology advanced. Mechanics usually used pounds per square inch for fuel, air and hydraulic pressure systems while the medical community used inches of mercury for human related systems. Pilots were used to inches, feet and miles for distances, so their navigational measurements were made in the traditional English measurement

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system. Weather was more scientific, and measurements were in the metric system, but weather information had to be transmitted to pilots who wanted the information in traditional formats. The result is that weather professionals use ***millibars***, isobars, etc., but translate the information into inches, feet and miles for the pilots. As aviation became more complex, it would have been wonderful if the various measurements had been changed to one, uniform system. That did not happen. The industry kept each measurement system and simply added more as time passed. In order to be successful in aviation today, you must be very familiar with all of the following:

Millibars

Pressure Measurement

Pressure:

Sea level pressure	=	14.7 pounds per square inch
	=	760 mm Hg
	=	1,013.2 millibars
	=	29.92 inches of Hg
	=	33 feet of water (saline)
	=	1 atmosphere

Temperature Measurement

Temperature:

Freezing water	=	0° Centigrade [C=5/9(F–32)]
	=	32° Fahrenheit [F=9/5C+32]
	=	273° Kelvin
Absolute “0”	=	0° Kelvin
	=	–273° Centigrade
Boiling water	=	100° Centigrade
	=	212° Fahrenheit
	=	373° Kelvin

Distance and Altitude Measurement

Flight levels

Distances:

Altitude	=	feet from the surface up to 18,000 ft.
	=	***Flight levels (FL***) each thousand feet above 18,000 ft. (between 18,000 ft. and 24,000 ft., both feet and flight level terminology is often used interchangeably)
	=	Meters
Courses	=	Statute miles (5,280 feet)
	=	Nautical miles
	=	Kilometers

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In today's aviation world, understanding all of these measurements is essential if one is to understand the profession. Many, many accidents have resulted from using the wrong measurement terminology.

Understanding Heat

Heat

Why study ***heat***? The answer is that humans are extremely sensitive to heat and can not tolerate very much variation in temperature without special protection. In most parts of the world, humans can not even live all day or all night without special assistance because of the heat, or the absence of it, during a normal 24-hour day. The heat of the daylight scorches and destroys our skin, while the decrease in temperatures at night can cause the body temperature to drop to fatal levels. Unless we understand heat, we can not do very much about the problem of the temperature changes encountered in flight, so let us explore heat a little.

Kinetic Energy Theory

Kinetic Energy Theory

Temperature

The study of heat starts with the ***Kinetic Energy Theory*** which is based upon the idea that heat is matter in motion. In addition, the theory presumes that all matter is in motion all of the time and that ***temperature*** is a measure of that motion. The greater the motion, the higher the temperature. Since motion is a form of energy, temperature is one method of measuring the energy of a substance. As humans, that measurement is important to us, because we require a very specific temperature (energy) level to exist, and stabilizing the temperature is essential to survival in a flight environment.

Absolute Zero

Kelvin (K)

Do you remember how temperatures are measured? There are numerous methods, and, unfortunately, somewhere within the field of aviation almost every method is used. As a result, we will have to know several of the measurement systems. The most obvious system of measurement, and the easiest to understand, is to simply measure the motion of matter. If the matter stops moving, the temperature is zero degrees. This is known as ***Absolute Zero,*** or zero degrees K. (The ***"K"*** stands for ***"Kelvin"*** and is in honor of the scientist who invented this method of measurement.) This idea is easy to understand since

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everything would be frozen solid if all the molecular motion of matter stopped. If a substance is heated until it melts, then determining the melting point of any substance simply requires observing the K scale at the instant the substance melts. Thus, ice melts at 273°K and boils (becomes a gas) at 373°K. The problem with this system of measurement is that it takes very sophisticated scientific equipment to estimate the point where all molecular motion stops, and very few societies in the world have that capability. Not only that, but modern science believes that even though there is no molecular movement at ***absolute "0",*** there is some molecular vibration.

Absolute Zero

Since water is the one constant for all human civilizations, it is reasonable to base temperature measurements on it, and that is exactly what most individuals have done. If water is used as the constant for measuring temperature, then everyone has a method of making an accurate temperature measurement system. The simplest of these water based measurement systems uses a hollow tube filled it with a substance, such as mercury, which easily expands and contracts. The tube is placed in water, and the level of the mercury is marked on the tube when the water changes from a liquid to a solid (***freezing***) and from a liquid to a gas (***boiling)***. The distance on the tube is then divided into 100 equal units. Each unit is 1°, and since there are 100 of them, the system is known as the centigrade system. Thus, water freezes at "0" C and boils at "100" C.

Freezing

Boiling

Unfortunately, some nations use a third system named in honor of ***Fahrenheit*** who used it in his laboratories. A hollow tube filled with mercury was used, but the tube was marked at regular intervals beginning at "0". When used, this measurement device recorded that water froze at the 32nd mark, and boiled at the 212th mark. Thus, we have a third temperature measurement system which records freezing water at 32°F and boiling water at 212°F.

Fahrenheit

Aviation uses all three of these temperature measurement systems, and the professional aviator must know and understand each system. Various aviation systems use the temperatures interchangeably, and confusion can cause serious accidents.

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