航空器制造工程专业英语

航空器制造与维修工程师必读

胡　静　主编

飞机知识英语说

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Aircraft Manufacture Engineering Professional English

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前　言

对于现代的航空器制造和维修人员，学好专业英语是从事航空器制造与维修工作的必备素质之一，因为英语在当今高度全球化社会体系当中的重要性已不言而喻,可以说它是全球的官方语言，甚至是民航系统使用的官方语言。因此，本书是为适应现代高等教育改革和卓越工程师培养的需要，为民航高等院校飞行器制造工程等专业编写的教材，也可供飞行器动力工程专业学生使用，还可为从事航空器维修工作的工程技术人员参考。

本书内容主要分为概述(包括飞机的发展、飞机设计、飞机制造过程)、飞行原理(流体力学、飞机稳定性、飞机构造)、飞机结构与系统(机翼、机身、飞机液压系统、燃油系统、操纵系统、起落架、空调、氧气系统、设备/装饰、防冰排雨、防火、气源系统、惰性气体系统、飞机电源、照明系统)、动力装置(动力装置、发动机构造)以及维修管理(技术出版物、维修管理、人为因素)5 个部分，共 26 课。每课内容的编排包括课文内容、专业词汇以及习题。

教材编写：第 1～6 课、第 13～15 课、第 18 课由胡静编写，第 7、8、16 课由谭娜编写，第 9～12 课、第 17 课由张宏伟编写，第 19～26 课由张铁纯编写。全书由胡静担任主编。

中国民航飞行学院龙江教授和中国民航大学张艳玲教授对本书初稿进行了审阅，并提出了许多宝贵意见，在此对他们的工作表示衷心的感谢。

限于编者水平，书中不足之处在所难免，敬请读者批评指正。

编　者

2015 年 1 月

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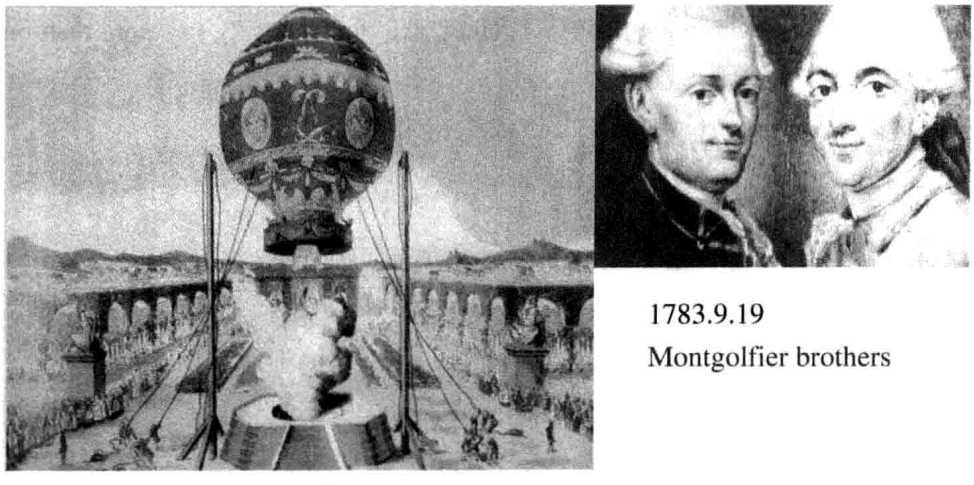
UNIT 01

DEVELOPMENT OF THE AIRPLANE

[1] Ever since man first saw a bird fly, man has wanted to fly. The first attempts were efforts to fly like a bird by attaching feathers to their arms and flapping. Those attempts were unsuccessful.

[2] **Hot Air Balloons**: The first successful air flight was in a hot air balloon, Fig. 1-1. In 1783 a few men invented the first flying machine by making the hot air balloon. A hot air balloon is a balloon filled with heated air. Since heated air is lighter than cool air, the balloon would rise into the sky. The pilot would ride in a basket attached to the balloon and control the height by adding and subtracting more heat.



1783.9.19
Montgolfier brothers

Fig. 1-1 Hot air balloon

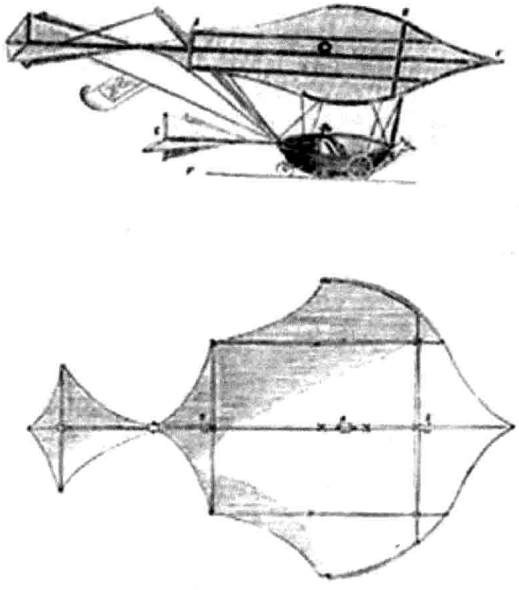
[3] The problem with hot air balloons is that you can not go the way you want. If the wind is blowing west, that means you would have to go west, too. During the Civil War hot air balloons were used by the armies to look at enemy troops.

[4] **First Airplanes**: The first airplane that was flown was a glider. A glider is a non-motorized flying machine (and very hard to control). Early gliders were launched from high places like cliffs and floated on the wind to the ground.

[5] A man named Sir George Cayel made the first glider that actually flew. His first glider didn't have passengers or a pilot, Fig. 1-2. It was too small and could not fit anyone in it. He made another that flew his coachman across a small valley. This glider was not launched from a cliff.

[6] During 1890 while Orville and Wilbur Wright were working in a bicycle shop, the Wright brothers got interested in flying. They learned that bicycles that were closer to the ground were faster. They read all the books they could find about airplanes to learn more. They then began building gliders near Kitty Hawk, North Carolina. The Wright brothers improved the glider. In 1899 they made a large, two-wing kite. After experimenting for a while on unmanned gliders, they made a glider where the pilot would control the airplane in the air. After working on glider experiments they found out how to steer a plane while in flight by developing a rudder (the tail of the plane) and flaps on the wings. With the rudder and the flaps, the pilot could control the direction of the airplane and the height.

[7] In December of 1903, the Wright brothers became the first people to successfully fly a plane with a person in it, Fig. 1-3. The plane flew one hundred twenty feet and flew only about twelve seconds. They had three successful flights that day, but Wilbur made the longest flight of 892 feet and stayed up for about 59 seconds. In 1903 the Wright brothers made their first powered airplane that they named the "flyer". It was a biplane (two winged plane) than had a 12 horse power engine that they had built themselves. The wings were 40 feet wide, wooden, and covered with cotton cloth. The pilot would lay on the lower wing on his stomach and steer the plane. In 1908 the Wright brothers finally made a plane that could fly for more than one and a half hours.



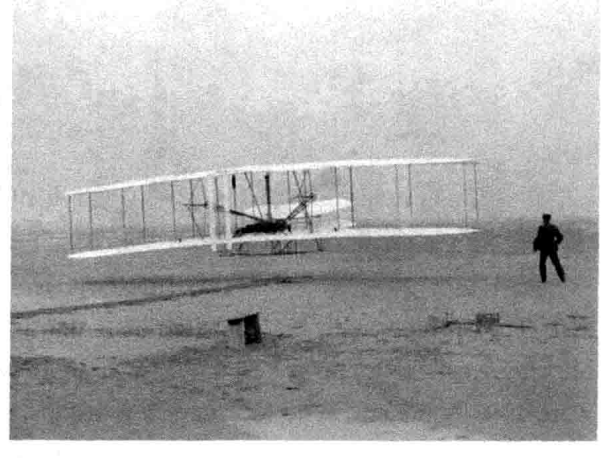


Fig. 1-2 Glider from 1852 by Sir George Cayel *Fig. 1-3 First flight by the Wright brothers*

[8] **Improvements to Airplanes**: In 1843 William S. Henson, an inventor, patented plans for an

airplane after trying to build a model airplane. When those plans failed he gave up on airplanes. His friend, John Stingfellow, tried making a model of Henson's model and succeeded. The plane launched, but could only stay in the air for a short time.

[9] In 1890 Clement Ader took off on the first steam powered plane (a plane with an engine, unlike the glider) that he had built himself. What was very unlucky about that was he could not fly it because he could not control it. Around the same time another inventor, Hiram Maxiam, built a steam powered flying machine. He tested his airplanes, but never really got them off the ground because they were too heavy and he could not control the flight.

[10] During 1894 Samuel Langley flew a steam powered plane and went 0.8 kilometers in one and a half minutes. Once Langley made another airplane, he got a pilot to steer once on October, 7 and once on December 8, but sadly the plane crashed in a lake.

[11] U.S. Army Lieutenant Thomas E. Selfridge was the first person killed in a plane crash. The military wanted to see how good the Wright brothers' airplane was for flying. On September 17, 1908, Selfridge went up in a plane with Orville Wright. When they were 75 feet in the air a propeller broke. The plane crashed, which killed Thomas and left Orville injured, but the Wright brothers still did not give up. In 1909, they got a contract from the military to build the first military plane.

[12] In 1911, Calbriath Rodgers made the first flight across the United States. He flew from Sheepshead Bay, New York to Long Beach, California. During the 84 days of flying, Rodgers crashed at least 70 times. He had to replace almost every part of the plane before he reached Long Beach. All together this journey took 3 days, 10 hours, and 24 minutes of time spent in the air. In November 1948, a sweptwing development of the Hawker Sea Hawk carrier-based jet fighter, the P.1052, made its first flight, followed on December 29 by the first flight of the Supermarine 10, a sweptwing version of the Supermarine Swift naval fighter. Both the Supermarine and Hawker designs were powered by the Rolls-Royce Nene centrifugal-flow turbojet, an engine that would have as profound an effect on American and Soviet jet aircraft design in the late 1940s as it did on the British.

[13] The United States was a relative latecomer to the jet age. But its emergence from World War II as the most powerful nation in the West, along with an economy that had not been devastated by the war, and the perceived Soviet threat, resulted in a mammoth American effort to develop jet aircraft. Although both American and Soviet jet designs were to get their greatest boost from the importation of British power plant and German sweptwing technology, it can safely be said that American designers, encouraged by generous financial support from the government, produced the most extensive and imaginative range of jet designs to fly during the 1940s.

[14] **Boeing Aircraft**: In order to get the market, the airplane has to be designed to cover the distances required by the passengers and the airplanes at that time. If the market is growing a great deal internationally, a new airplane tailored to the transcontinental routes with poor ability

to do the international job, will face a severely reduced market. If market studies show a sufficient need for aircraft of a shorter range, then you may design for the 700 to 1000 mile range successfully, e.g. the DC-9 and the 737. Companies look for niches that can be filled in the spectrum of airplane range and payload. Refer to the Fig. 1-4.

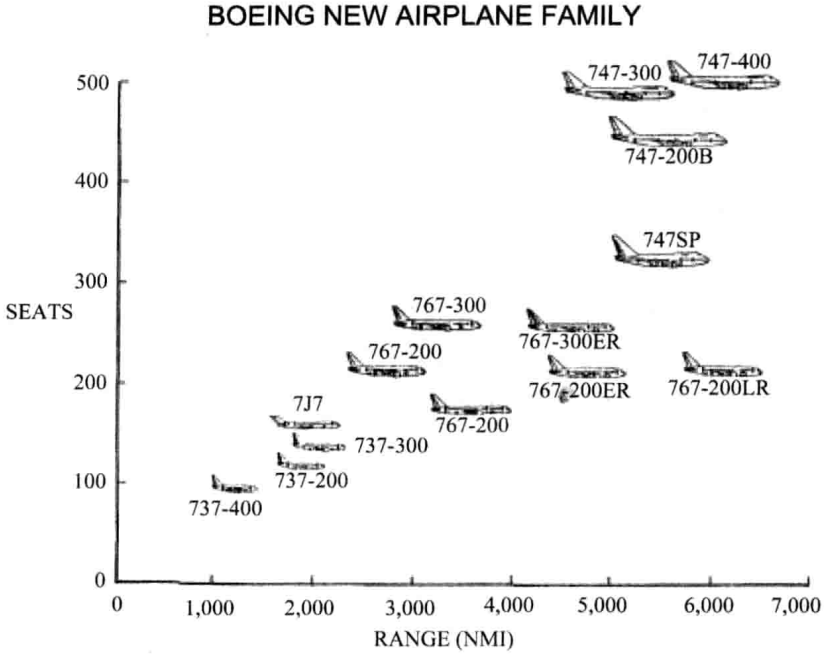


Fig. 1-4 Boeing Family

[15] The 737, including B737-200/-300/-400/-500, is a short-to-medium-range airplane and based on a key Boeing philosophy of delivering added value to airlines with reliability, simplicity and reduced operating and maintenance costs. The newest members of the Boeing 737 family—the 737-600/-700/-800/-900ER models—continue the 737's pre-eminence as the world's most popular and reliable commercial jet transport.

[16] The 747-400 incorporates major aerodynamic improvements over earlier 747 models, including the addition of winglets to reduce drag, new avionics, a new flight deck and the latest in-flight entertainment systems. And, the 747 continues to be the world's fastest subsonic jetliner, cruising at Mach .855—or 85.5 percent of the speed of sound. With the lowest operating cost per ton-mile in the industry, the new-technology Boeing 747-400 Freighter is the all-cargo transport member of the 747-400 family. It can carry twice as much cargo, twice as far, as the competitor's leading freighter.

[17] Today's Boeing 767 family includes four models—the 767-200ER, 767-300ER and 767-400ER passenger jetliners and the 767 Freighter, based on the 767-300ER fuselage. Sized between the single-aisle 737 Next Generation and the twin-aisle 777, the versatile 767 has earned a reputation among airlines for its profitability and comfort. The 767-400ER enjoys significant

advantages in operating economics over other 240- to 300-seat airplanes. Unsurpassed comfort for intercontinental passengers, 3,580 cubic feet (129.7 cu. m) of lower hold cargo space, and commonality with other Boeing jetliners make the 767-400 an excellent revenue generator with exceptionally high reliability and low maintenance costs.

[18] The 777-300ER extends the 777 family's span of capabilities, bringing twin-engine efficiency and reliability to the long-range market. The airplane carries 365 passengers up to 7,930 nautical miles (14,685 km). Boeing incorporated several performance enhancements for the 777-300ER, extending its range and payload capabilities. Excellent performance during flight testing, combined with engine efficiency improvements and design changes that reduce drag and airplane weight, contributed to the increased capability. The benefits were also applied during development of the 777-200LR and the 777 Freighter.

[19] In conjunction with an announcement that the Boeing 7E7 will be made primarily of composite materials, Boeing released a new image of the super efficient airplane. Work on development of the airplane continues on schedule. More than 40 airlines from around the world are engaged in dialogues with Boeing about the 7E7.

[20] **Airbus Aircraft**: Airbus jetliners have become the aircraft of choice for operators worldwide—from low-cost carriers to full-service airlines flying many of the longest routes around the globe. Airbus' highly successful jetliner product line ranges in size from the 107-seat single-aisle A318 to the double-deck A380 widebody (Fig. 1-5), which is the world's largest commercial aircraft in service today.

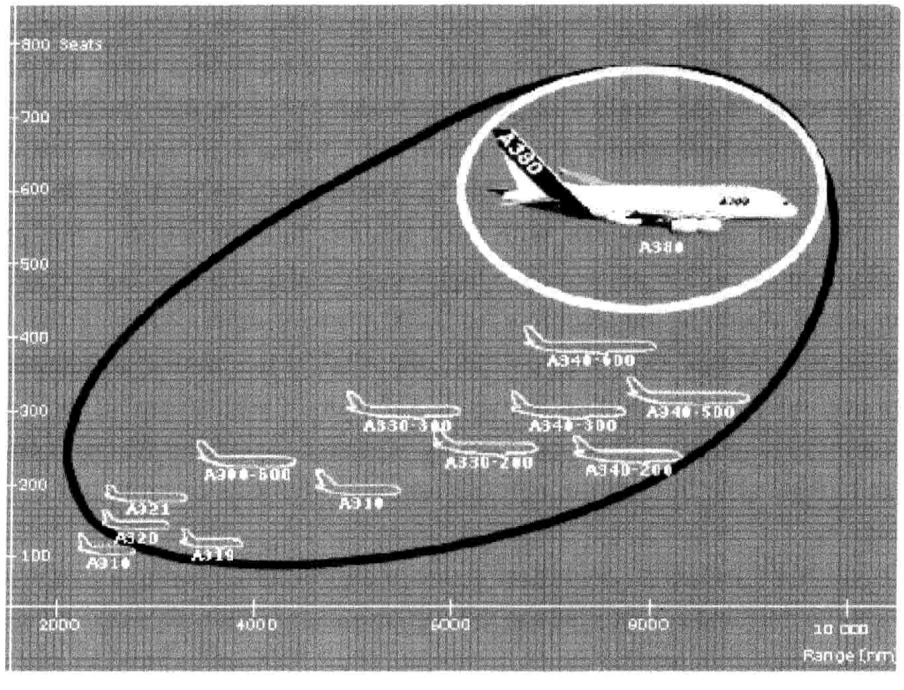


Fig. 1-5 Airbus Aircraft

[21] The A320 family is based on a common aircraft type with the same wide cabin cross-section, which is available in four fuselage lengths: the A318, A319, A320 and A321 – all of which share the same systems, cockpits, operating and maintenance procedures, and pilot type rating. They cover the market from 100 to 220 seats and currently fly on ranges of up to 3,700 nautical miles. The family's cornerstone aircraft is the A320, which accommodates 150 passengers in a typical two-class arrangement, and up to 180 with high-density seating. The stretched-fuselage A321 version seats 185 passengers in the two-class layout, and up to 220 for a high-density cabin. The shorter-fuselage A319 has a 124-passenger capacity in the two-class configuration, and up to 156 in high-density, while the smallest—Airbus' A318—seats 107 passengers in the two-class cabin and 132 with high-density seating.

[22] The A330 is the most cost efficient wide-body twin aircraft in operation. The A330 family has five members – the A330-200, A330-300, A330-200F, A330 Prestige and A330 MRTT—which cover all market segments with one twin-engine aircraft type. The combination of low operating costs, high efficiency, flexibility and optimised performance makes the A330 family popular with an ever-increasing operator base. Continuous improvement brings the latest technology onboard the A330. Commonality is further shared across the Airbus product line of widebody and single-aisle aircraft through the use of fly-by-wire controls and cockpits with similar layouts. The A330 provides exceptional operational flexibility at lowest cost, with right-sized cabins for passenger, freight, VIP and multi-role military applications. It combines Airbus' flight-by-wire technology and modern onboard systems with high aerodynamic efficiency for a highly productive aircraft.

[23] The four-engine A340 has greater range at lower cost than any other long-range widebody commercial jetliner. Its market-matched capacity and unique economics make it a pathfinder to profitability on some of the world's longest, most demanding airline routes. The aircraft's extended reach and spacious interior also tailors it for VVIP and government use with highly discerning customers. Four versions of the A340 have been produced by Airbus: the A340-200, A340-300, A340-500 and A340-600. With their different fuselage lengths, this product line accommodates from 240 to 359 passengers in highly comfortable two-class cabin configurations, providing extended operating ranges of up to 9,000 nautical miles. Utilising the same basic fuselage and wing as Airbus' twin-engine A330, the A340 shares similar airframe structures, components and systems – providing a true aircraft family with different versions to meet operators' varied requirements. This commonality is shared across the Airbus product line of widebody and single-aisle aircraft through the use of fly-by-wire controls and cockpits with similar layouts.

[24] The A350 XWB jetliner is shaping the future of air travel by offering a complete family of new-generation aircraft that is best suited to the market's requirements for size, range, revenue generation, passenger comfort and the environment. The A350 family provides true long-range capability with seating capacities from 250 to 400-plus passengers. This enables airlines to best

match their A350 XWB fleets to route capacity demands, guaranteeing optimum revenue potential and excellent operating efficiency. Over 70 per cent of the A350 XWB's weight-efficient airframe is made from advanced materials, combining 53 per cent of composite structures with titanium and advanced aluminium alloys. The aircraft's innovative all-new Carbon Fibre Reinforced Plastic (CFRP) fuselage results in lower fuel consumption, as well as easier maintenance. The aircraft family concept, proven by Airbus with its other jetliners, also ensures optimal efficiency through the A350 XWB's commonality in engines, systems and spare parts, while also enabling pilots to fly all three versions with a single type rating.

[25] The double-deck A380 is the world's largest commercial aircraft flying today, with capacity to carry 525 passengers in a comfortable three-class configuration, and up to 853 in a single-class configuration that provides wider seats than its competitor. Overall, the A380's two decks offer 50 per cent more floor surface than any other high-capacity aircraft. With its range of 8,300 nautical miles, the A380 is the ideal solution to alleviate traffic congestion at busy airports, while coping with market growth. It has two full-length passenger levels with true widebody dimensions: a main deck and an upper deck, which are linked by fixed stairs forward and aft.

[26] Airplane travel has improved a great deal since the first efforts of the Wright brothers. Airplanes now travel thousands of miles at altitudes of more than 7 miles, carrying over several hundreds of passengers. Those passengers rest in comfortable seats instead of on their stomachs like Orville did. Jet engines have replaced propellers and speeds are greater than 600 miles per hour. Not even the Wright brothers could have imagined what air travel would be like today.

New Words and Expressions

balloon[bə'lu:n] *n.*	气球；气囊
pilot['pailət] *n.*	驾驶员，飞行员
civil['sivl] *adj.*	公民的，民用的
airplane['eəplein] *n.*	飞机
glider['glaidə] *n.*	滑翔机，滑翔器
launch[lɔ:ntʃ] *vt.*, *vi.*	发射，起飞
cliff[klif] *n.*	悬崖，峭壁
passenger['pæsindʒə] *n.*	乘客
coachman['kəutʃmæn] *n.*	马车夫
valley['væli] *n.*	山谷
bicycle['baisikl] *n.*	自行车
wing[wiŋ] *n.*	机翼
unmanned['ʌn'mænd] *adj.*	无人驾驶的
steer[stiə] *vt.*	使转弯

rudder['rʌdə] *n.* 方向舵
flap[flæp] *n.* 襟翼
biplane['baiplein] *n.* 双翼飞机
horse power 马力
model['mɔdəl] *n.* 模型
steam[sti:m] *n.* 蒸汽动力
crash[kræʃ] *vi.* 坠毁
propeller[prə'pelə] *n.* 螺旋桨；推进器
military['militəri] *n.* 军方；军队
swept-wing['swept,wiŋ] *adj.* 后掠翼式的
jet fighter 喷气式战斗机
philosophy[fi'lɔsəfi] *n.* 原理；哲学
reliability[ri'laiəbiliti] *n.* 可靠性
maintenance cost 维护成本
commercial[kə'mə:ʃəl] *adj.* 商业的；商务的
aerodynamic[,ɛərəudai'næmik] *adj.* 空气动力学的
winglet['wiŋlit] *n.* 小翼
avionics[,eivi'ɔniks] *n.* 航空电子设备
subsonic['sʌb'sɔnik] *adj.* 亚音速的
jetliner['dʒet,lainə] *n.* 喷气客机
cruise[kru:z] *n.* 巡航
freighter['freitə] *n.* 货机
cargo['kɑ:gəu] *n.* 货物
fuselage['fju:zilɑ:ʒ] *n.* 机身
efficiency[i'fiʃənsi] *n.* 效率
payload['pei,ləud] *n.* 有效载荷
drag[dræg] *n.* 阻力
composite['kɔmpəzit] *adj.* 复合的
configuration[kən,figju'reiʃən] *n.* 构造；布局
widebody['waid,bɔdi] *adj.* 宽体式的
cabin['kæbin] *n.* 机舱
flight-by-wire 电传操纵
fleet[fli:t] *n.* 机队
titanium[tai'teiniəm] *n.* 钛
aluminium alloys 铝合金
Carbon Fibre Reinforced Plastic(CFRP) 碳纤维强化塑料
fuel[fjuəl] *n.* 燃料；燃油
spare[spɛə] *adj.* 备用的，备份的

Exercises

1. Mark each of the following statements True or False.

1) Since heated air is heavier than cool air, the balloon would rise into the sky.
2) With the rudder and the flaps, the pilot could control the direction of the airplane and the height.
3) It was a biplane (two winged plane) that had a 10 horse power engine that they had built themselves.
4) Clement Ader took off on the first steam powered plane (a plane with an engine, unlike the glider) that he had built himself, but it was too heavy to control.
5) The United States was a relative early comer to the jet age.
6) In conjunction with an announcement that the Boeing 7E7 will be made primarily of composite materials, Boeing released a new image of the super efficient airplane.
7) Offering about two third more seating and far more available floor space than its closest competitor, the A380 will deliver an unparalleled level of comfort, with wider seats and aisles, open spaces for passengers to stretch their legs and access to lower-deck amenities.
8) The A380's modern technology and economies of scale provide 15-20 per cent higher seat-mile costs and 10 per cent more range than today's largest aircraft.
9) Because new generation engines and advanced wing and undercarriage design and technology, the A380 will not only comply with current noise limits but will be significantly quieter than today's largest airliner, meeting strict local regulations such as QC2 for departure at London airports.
10) The freighter version, the A380F, will carry a payload of 150 tonnes (330,000 lbs) over 10,400 km./5,600 nm.

2. Complete the following sentences with appropriate words or phrases.

1) The pilot would ride in a _____attached to the balloon and control the height by adding and subtracting more heat.
2) After experimenting for a while on _____gliders, they made a glider where the pilot would control the airplane in the air.
3) The wings were 40 feet wide, wooden, and covered with _____.
4) In November 1948, a_____development of the Hawker Sea Hawk carrier-based jet fighter.
5) Companies look for niches that can be filled in the_____of airplane range and payload.
6) The 747-400 is the world's fastest_____ jetliner, cruising at Mach .85.
7) While meeting the most stringent international _____requirements, the A380 embodies the very latest technologies for materials, systems and industrial processes.
8) The economic fuel _____of the A380—around 13 per cent lower fuel burn than its

closest competitor—will also help reduce the impact of exhaust gases on the atmosphere.

9) The A330 provides exceptional operational flexibility at lowest cost, with right-sized cabins for_____, freight, VIP and multi-role military applications.

10) Jet engines have replaced_____and speeds are greater than 600 miles per hour.

3. Translate the followings into Chinese.

1) **Airplane**: An engine-driven, fixed-wing aircraft heavier than air, that is supported in flight by the dynamic reaction of the air against its wings.
2) **Aircraft**: Any weight-carrying device designed to be supported by the air. Airplanes, helicopters, gliders, and balloons are all types of aircraft.
3) **Biplane**: An airplane having two main supporting aerodynamic surfaces (wings). The wings of a biplane are normally mounted so that one is approximately above the other.
4) **Payload**: The amount of load carried by a vehicle over and above the load necessary for the operation of the vehicle. Payload is actually the amount of revenue-producing load an aircraft can carry.
5) **Composite**: Something made up of different materials combined in such a way that the characteristics of the resulting material are different from those of any of the components.
6) **Flight deck(aircraft compartment)**: The compartment in a large aircraft in which all the flight, engine, communications, and navigation controls are located.
7) **Glider (type of aircraft)**: An aircraft having no engine, which is capable of free flight only while it is descending through the air. Gliders are launched by towing them behind an airplane, pulling them into the air with an automobile, or shooting them into the air with a catapult. High-performance gliders are called sailplanes.
8) **Cockpit**: The portion of an aircraft or a spacecraft from which the flight crew controls the vehicle.
9) **Airliner:** A large transport-type aircraft used in air commerce for the transportation of passengers and/or cargo.
10) **Fuselage (aircraft component)**: The body, or central structural component of an airplane. The passengers and flight crew are housed in the fuselage, and the wings and tail attach to it. In most single-engine airplanes, the engine and landing gear attach to the fuselage.

4. Reading Material.

On December 17, 1903 Wilbur Wright watched in amazement as his brother Orville Wright took off and landed the world's first powered airplane flight. The flight lasted twelve seconds and traveled a distance of one hundred and twenty feet, which was less than the length of many of today's commercial airliners. The Wright brothers flew three other flights on that historical day as well, the longest of them being the eight hundred fifty two feet, fifty nine second record flight piloted by Wilbur. The brothers encountered many obstacles they had to overcome before creating a successful aircraft. One of the obstacles was finding an engine that was light enough

yet powerful enough to get the plane off the ground. Another problem they faced was keeping the plane stabilized which they accomplished by shifting themselves from side to side. The two brothers also had to design their own airplane propeller.

Bernoulli's Principal is perhaps of the most important factor in allowing an aircraft to leave the ground. The wings shape allows the air to move faster over the top side of the wing which creates lift. Many forces act on an airplane in order to allow it to lift off and fly. One of these forces is thrust. Thrust provides and aircraft the necessary velocity needed in order to generate lift which is another force. Thrust is created by propellers and engines. Lift is another force which is created when air travels faster over the top of an airplane wing than it does on the bottom generating lift. The heavier that aircraft is the more thrust is required to generate lift. Drag is the opposing force to thrust and can be reduced depending on the shape of the plane. Drag is created by every part of an airplane, it is the skin friction between the molecules of the air and the solid surface of the aircraft. Gravity affects airplanes the same way it would as a paper airplane pulling it back toward the ground and acting against all 3 of the other forces.

The shape of a birds wing is similar to the shape of a plane's wing which allows it to fly a glide, however a bird can change direction quickly because of its ability to tilt its wings in different directions. The overall shape of a birds body in flight is also very aerodynamic and creates minimal drag. Propeller acts as a spinning wing and pulls an airplane forward providing it with the necessary thrust to lift off of the ground. The Wright brothers created the first propeller in order to lift their aircraft off the ground. A helicopter is different from an airplane because it can take off and land vertically, and also hover in place. The angle at which the helicopter blades are facing allows a helicopter to fly and change directions. The flight of a helicopter also depends on the speed in which the blades are spinning and in what direction.

Jet engines provide an airplane with a great amount of forward movement allowing a plane to move very fast. Air is sucked into the jet engine through the front fan. The pressure of the air is then raised by a compressor and sprayed with fuel. An electric spark then ignites and is blasted through a nozzle in the back causing tremendous forward thrust. Rocket engines are engines driven by reaction. A good example of how a rocket works is a blown up balloon with air. The balloon does not move when it is closed, but when the back is released it shoots forward. The balloon shoots forward because it is the reaction of the air shoot out of the back, just as a rocket shoots forward as its fuel is shot out of the back.

UNIT 02

AIRCRAFT DESIGN

[1] The process of designing an aircraft, is generally divided into three distinct phases: conceptual design, preliminary design, and detail design. Each phase has its own unique characteristics and influence on the final product. These phases all involve aerodynamic, propulsion, and structural design, and the design of aircraft systems.

[2] **Design phases**: Conceptual design activities are characterized by the definition and comparative evaluation of numerous alternative design concepts potentially satisfying an initial statement of design requirements. The conceptual design phase is iterative in nature. Design concepts are evaluated, compared to the requirements, revised, reevaluated, and so on until convergence to one or more satisfactory concepts is achieved. During this process, inconsistencies in the requirements are often exposed, so that the products of conceptual design frequently include a set of revised requirements.

[3] During preliminary design, one or more promising concepts from the conceptual design phase are subjected to more rigorous analysis and evaluation in order to define and validate the design that best meets the requirements. Extensive experimental efforts, including wind-tunnel testing and evaluation of any unique materials or structural concepts, are conducted during preliminary design. The end product of preliminary design is a complete aircraft design description including all systems and subsystems. During detail design the selected aircraft design is translated into the detailed engineering data required to support tooling and manufacturing activities.

[4] **Requirements**: The requirements used to guide the design of a new aircraft are established either by an emerging need or by the possibilities offered by some new technical concept or invention. Requirements can be divided into two general classes: technical requirements (speed, range, payload, and so forth) and economic requirements (costs, maintenance characteristics, and so forth).

[5] **Aerodynamic design**: Initial aerodynamic design centers on defining the external geometry and general aerodynamic configuration of the new aircraft.