|  |
| --- |
| **Lesson 1.3 Flight Planning and Navigation** |

**Preface**

Effectively navigating to a destination is a skill that humankind has developed out of necessity. Very early in our history, humans needed to navigate to locate food and to return home. Sailors navigated across oceans, sometimes for the first time. Today your family can drive to your favorite vacation destination without getting lost. Pilots navigate their aircraft to airports in other cities, while astronauts navigate a space vehicle to another planet. Computer simulators provide opportunities for the development of navigation skills.

Computer simulators are highly integrated into aviation training programs. Difficult conditions which rarely occur in the real world can be realistically simulated. Crews learn to manage such conditions without endangering crew or equipment. These simulators are used for planning and then executing the flight to verify the plan’s accuracy.

This lesson will introduce the students to the fundamentals of flight, navigation and the use of simulators.

**Concepts**

1.     Simulations are widely used in the aerospace industry to develop skills which can be effectively applied to the actual device.

2.     Each flight should be planned in advance of the actual flight.

3.     Pilots then apply the principles of navigation to safely travel to their destinations.

4.     The Global Positioning System, GPS, is a complex system designed to provide accurate location information to many users.

5.     The history of navigation is intertwined with technology development.

6.     Air traffic is coordinated within a complex system to improve safety and efficiency.

**Standards and Benchmarks Addressed**

***Standards for Technological Literacy***

|  |
| --- |
| **Standard 1:  Students will develop an understanding of the characteristics and scope of technology.** |
| **BM J:** | The nature and development of technological knowledge and processes are functions of the setting. |
| **BM K:** | The rate of technological development and diffusion is increasing rapidly.  |
| BM L: | Inventions and innovations are the results of specific, goal-directed research. |
| **BM M:** | Most development of technologies these days is driven by the profit motive and the market. |
| **Standard 2:  Students will develop an understanding of the core concepts of technology.** |
| **BM W:** | Systems’ thinking applies logic and creativity with appropriate compromises in complex real-life problems.  |
| **BM X:** | Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems.  |
| **BM Y:** | The stability of a technological system is influenced by all of the components in the system especially those in the feedback loop.  |
| **BM Z:** | Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.  |
| **BM AA:** | Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.  |
| **BM BB:** | Optimization is an on going process or methodology of designing or making a product and is dependent on criteria and constraints. |
| **BM CC:** | New technologies create new processes.  |
| **BM FF:** | Complex systems have many layers of controls and feedback loops to provide information. |
| **Standard 3:  Students will develop an understanding of the relationships** **among technologies and the connections between technology and other fields of study.** |
| **BM G:** | Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function |
| **BM H:** | Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.  |
| **BM I:** | Technological ideas are sometimes protected through the process of patenting. The protection of a creative idea is central to the sharing of technological knowledge. |
| **BM J:** | Technological progress promotes the advancement of science and mathematics. Likewise, progress in science and mathematics leads to advances in technology. |
| **Standard 4:  Students will develop an understanding of the cultural, social, economic, and political effects of technology.** |
| **BM H:** | Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.  |
| **BM I:** | Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects.  |
| **BM J:** | Ethical considerations are important in the development, selection, and use of technologies.  |
| **BM K:** | The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees. |
| **Standard 5:  Students will develop an understanding of the effects of** **technology on the environment.** |
| **BM J:** | The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.  |
| **BM K:** | Humans devise technologies to reduce the negative consequences of other technologies.  |
| **BM L:** | Decisions regarding the implementation of technologies involve the weighing of tradeoffs between predicted positive and negative effects on the environment. |
| **Standard 6:  Students will develop an understanding of the role of society in the development and use of technology.**  |
| **BM H:** | Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values.  |
| **BM I:** | The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures.   |
| **BM J:** | A number of different factors, such as advertising, the strength of the economy, the goals of a company and the latest fads contribute to shaping the design of and demand for various technologies. |
| **BM I:** | The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures.   |
| **Standard 7:  Students will develop an understanding of the influence of** **technology on history.**  |
| **BM G:** | Most technological development has been evolutionary, the result of a series of refinements to a basic invention.  |
| **BM H:** | The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials.  |
| **BM I:** | Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.  |
| **BM J:** | Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how.  |
| **BM N:** | The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time. |
| **BM O:** | The Information Age places emphasis on the processing and exchange of information. |
| **BM G:** | Most technological development has been evolutionary, the result of a series of refinements to a basic invention.  |
| **BM H:** | The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials.  |
| **BM I:** | Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.  |
| **BM O:** | The Information Age places emphasis on the processing and exchange of information. |
| **Standard 8:  Students will develop an understanding of the attributes of design.**  |
| **BM H:** | The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.   |
| **BM I:** | Design problems are seldom presented in a clearly defined form.  |
| **BM J:** | The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.   |
| **BM K:** | Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. |
| **Standard 9:  Students will develop an understanding of engineering design.**  |
| **BM J:** | Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. |
| **Standard 10:  Students will develop an understanding of the role of** **troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** |
| **BM I:** | Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.  |
| **BM J:** | Technological problems must be researched before they can be solved.  |
| **BM K:** | Not all problems are technological, and not every problem can be solved using technology.  |
| **BM L:** | Many technological problems require a multidisciplinary approach. |
| **Standard 11:  Students will develop abilities to apply the design process.**  |
| **BM M:** | Identify the design problem to solve and decide whether or not to address it. |
| **BM N:** | Identify criteria and constraints and determine how these will affect the design process.   |
| **BM O:** | Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.   |
| **BM P:** | Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.   |
| **BM Q:** | Develop and produce a product or system using a design process.    |
| **BM R:** | Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. |
| **Standard 12:  Students will develop the abilities to use and maintain technological products and systems.**  |
| **BM L:** | Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.  |
| **BM N:** | Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision.  |
| **BM O:** | Operate systems so that they function in the way they were designed.  |
| **BM P:** | Use computers and calculators to access, retrieve, organize and process, maintain, interpret, and evaluate data and information in order to communicate. |
| **Standard 13:  Students will develop the abilities to assess the impacts of products and systems.**  |
| **BM J:** | Collect information and evaluate its quality.  |
| **Standard 17:  Students will develop an understanding of and be able to select and use information and communication technologies.**  |
| **BM L:** | Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information. |
| **BM M:** | Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.  |
| **BM N:** | Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.  |
| **BM O:** | Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. |
| **BM P:** | There are many ways to communicate information, such as graphic and electronic means. |
| **BM Q:** | Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. |
| **Standard 18:  Students will develop an understanding of and be able to select and use transportation technologies.**  |
| **BM J:** | Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.  |
| **BM K:** | Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another.   |
| **BM L:** | Transportation services and methods have led to a population that is regularly on the move.   |
| **BM M:** | The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques. |
| **Standard 19:  Students will develop an understanding of and be able to select and use manufacturing technologies.**  |
| **BM L:** | Servicing keeps products in good operating condition.  |
| **BM O:** | Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production.  Optimization is an on going process or methodology of designing or making a product and is dependent on criteria and constraints. |
| **BM P:** | The interchangeability of parts increases the effectiveness of manufacturing processes.   |
| **BM R:** | Marketing involves establishing a product’s identity, conducting research on its potential, advertising it, distributing it, and selling it. |
| **Standard 20:  Students will develop an understanding of and be able to select and use construction technologies.**  |
| **BM J:** | Infrastructure is the underlying base or basic framework of a system.   |
| **BM K:** | Structures are constructed using a variety of processes and procedures.   |
| **BM L:** | The design of structures includes a number of requirements.   |
| **BM M:** | Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use.   |
| **BM N:** | Structures can include prefabricated materials. |

***National Science Education Standards***

**Unifying Concepts and Processes:**  As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes.

        **Systems, order, and organization**

        **Evidence, models, and explanation**

        **Change, constancy, and measurement**

        **Evolution and equilibrium**

        **Form and function**

**Science As Inquiry Standard A:** As a result of activities in grades 9-12, all students should develop

        **Abilities necessary to do scientific inquiry**

        **Understanding about scientific inquiry**

**Physical Science Standard B:** As a result of activities in grades 9-12, all students should develop an understanding of

        **Motions and forces**

        **Conservation of energy and increase in disorder**

        **Interactions of energy and matter**

**Earth and Space Science Standard D:** As a result of activities in grades 9-12, all students should develop an understanding of

        **Energy in the earth system**

**Science and Technology Standard E:** As a result of activities in grades 9-12, all students should develop

        **Abilities of technological design**

        **Understandings about science and technology**

**Science in Personal and Social Perspectives Standard F:** As a result of activities in grades 9-12, all students should develop understanding of

        **Natural and human-induced hazards**

        **Science and technology in local, national, and global challenges**

**History and Nature of Science Standard G:** As a result of activities in grades 9-12, all students should develop understanding of

        **Science as a human endeavor**

        **Nature of scientific knowledge**

        **Historical perspectives**

***Principles and Standards for School Mathematics***

|  |  |
| --- | --- |
| **Number and Operations** | Instructional programs from pre-kindergarten through grade 12 should enable all students to understand numbers, ways of representing numbers, relationships among numbers, and number systems; understand meanings of operations and how they relate to one another; compute fluently and make reasonable estimates. |
| **Algebra** | Instructional programs from pre-kindergarten through grade 12 should enable all students to understand patterns, relations, and functions; represent and analyze mathematical situations and structures using algebraic symbols; use mathematical models to represent and understand quantitative relationships; analyze change in various contexts. |
| **Geometry** | Instructional programs from pre-kindergarten through grade 12 should enable all students to analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; specify locations and describe spatial relationships using coordinate geometry and other representational systems; apply transformations and use symmetry to analyze mathematical situations; use visualization, spatial reasoning, and geometric modeling to solve problems. |
| **Measurement** | Instructional programs from pre-kindergarten through grade 12 should enable all students to understand measurable attributes of objects and the units, systems, and processes of measurement; apply appropriate techniques, tools, and formulas to determine measurements. |
| **Problem Solving** | Instructional programs from pre-kindergarten through grade 12 should enable all students to build new mathematical knowledge through problem solving; solve problems that arise in mathematics and in other contexts; apply and adapt a variety of appropriate strategies to solve problems; monitor and reflect on the process of mathematical problem solving. |
| **Communication** | Instructional programs from pre-kindergarten through grade 12 should enable all students to organize and consolidate their mathematical thinking through communication; communicate their mathematical thinking coherently and clearly to peers, teachers, and others; analyze and evaluate the mathematical thinking and strategies of others; use the language of mathematics to express mathematical ideas precisely. |
| **Connections** | Instructional programs from pre-kindergarten through grade 12 should enable all students to recognize and use connections among mathematical ideas; understand how mathematical ideas interconnect and build on one another to produce a coherent whole; recognize and apply mathematics in contexts outside of mathematics. |
| **Representation** | Instructional programs from pre-kindergarten through grade 12 should enable all students to create and use representations to organize, record, and communicate mathematical ideas; select, apply, and translate among mathematical representations to solve problems; use representations to model and interpret physical, social, and mathematical phenomena. |

***Standards for English Language Arts***

|  |  |
| --- | --- |
| **Standard 4** | Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. |
| **Standard 5** | Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes. |
| **Standard 8** | Students use a variety of technological and informational resources (e.g. libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. |
| **Standard 12** | Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information). |

**Performance Objectives**

*It is expected that students will:*

       Explain the progression of navigation technology and its influence on navigation.

       Demonstrate aircraft control through the use of a flight simulator.

       Plan a flight and accurately navigate this plan using a flight simulator.

       Explain why simulators are valuable tools for preparing pilots to fly aircraft.

       Use the Global Positioning System, GPS, unit to navigate.

**Assessment**

*Explanation*

       Students will explain the differences between atmospheric flight and space flight.

       Students will explain why navigation is hindered by existing technology.

       Explain why simulators are valuable tools for preparing pilots to fly aircraft.

*Interpretation*

       Students will pilot a simulated aircraft.

       Students will demonstrate the flight characteristics of an airplane through the use of a flight simulator.

       Students will use a map to determine a compass heading and distance from an origin to a destination.

*Application*

       Students will make an accurate flight plan in their local area.

       Students will estimate the direction and time it takes to reach a destination.

       Students will create a map and use it to navigate.

*Perspective*

       Students will describe which factors early explorers compensated for to improve navigation accuracy.

*Empathy*

       Students will describe explain how the technologies of today would have assisted Columbus crossing the Atlantic Ocean for the first time.

       Students will describe the dangers faced by space explorers.

*Self-knowledge*

       Students will describe the skills needed to plan an actual flight.

       Students will reflect on their work in journals by recording their thoughts and ideas.

**Essential Questions**

1.     How can skills and knowledge learned from a simulator be applied to a physical aircraft?

2.     What are the advantages and disadvantages of training to fly in a simulator versus a real aircraft.

3.     How important is technology to a navigator?

4.     What risks are present during space flight?

**Key Terms**

|  |  |
| --- | --- |
| **Term** | **Definition** |
| **AGL** | Above Ground Level. Altitude expressed in feet measured above ground level. |
| **ADF** | Automatic Direction Finder. An aircraft radio navigation system which senses and indicates the direction to an L/MF non-directional radio beacon (NDB) ground transmitter. |
| **Bearing** | The horizontal direction to or from any point, usually measured clockwise from true north, magnetic north, or some other reference point through 360 degrees. |
| **Dead Reckoning** | Navigation of an airplane solely by means of computations based on airspeed, course, heading, wind direction and speed, groundspeed, and elapsed time. |
| **DME** | Distance Measuring Equipment. Equipment (airborne and ground) used to measure, in nautical miles, the slant range distance of an aircraft from the DME navigational aid. |
| **FMS** | Flight Management System. A computer system that uses a large database to allow routes to be preprogrammed and fed into the system by means of a data loader. |
| **GA** | All civil aviation operations other than scheduled air services and nonscheduled air transport operations for remuneration or hire. |
| **GPS** | Global Positioning System. A system which provides highly accurate position and velocity information and precise time, on a continuous global basis, to an unlimited number of properly equipped users. |
| **IFR** | Instrument Flight Rules. Rules governing the procedures for conducting instrument flight. |
| **ILS** | Instrument Landing System. A precision instrument approach system which normally consists of the following electronic components and visual aids: localizer, glideslope, outer marker, middle marker, and approach lights. |
| **Indicated Airspeed** | The speed shown on the aircraft airspeed indicator. |
| **INS** | Inertial Navigation System. An RNAV system which is a form of self-contained navigation. |
| **Knots** | Measure of the speed of aircraft and boats measured as nautical mile per hour or 6076 feet per hour. |
| **LAAS** | Local Area Augmentation System. Ground-based augmentation to GPS that focuses its service on the airport area (approximately 20-30 mile radius) for precision approach, departure procedures, and terminal area operations. |
| **L/MF** | Low or Medium Frequency. A frequency range between 190 and 535 kHz with the medium frequency above 300 kHz. |
| **LORAN** | Long Range Navigation. An electronic navigational system by which hyperbolic lines of position are determined by measuring the difference in the time of reception of synchronized pulse signals from two fixed transmitters. |
| **Magnetic Course** | Course of a vessel in relation to magnetic north. |
| **Magnetic Deviation** | Amount by which a ship’s magnetic compass needle points to one side or the other of magnetic north. |
| **Magnetic Variation** | A compass “error” resulting from the fact that at most points on the Earth’s surface the direction of the magnetic lines of force is not toward the geographic North Pole or South Pole. |
| **MSL** | Mean Sea Level. |
| **NDB** | Non-directional Beacon. An L/MF or UHF radio beacon transmitting non-directional signals whereby the pilot of an aircraft equipped with direction-finding equipment can determine their bearing to or from the radio beacon and "home" on or track to or from the station. |
| **Pilotage** | Navigation by visual reference to landmarks. |
| **RNAV** | Area Navigation (RNAV) provides enhanced navigational capability to the pilot. |
| **Sextant** | A sextant is a tool for measuring the angular altitude of a star above the horizon. |
| **TACAN** | Tactical Air Navigation. An ultra-high frequency electronic rho-theta air navigation aid which provides suitably equipped aircraft a continuous indication of bearing and distance to the TACAN station. |
| **True Airspeed** | The airspeed of an aircraft relative to undisturbed air. |
| **True Course** | A course corrected for variation and deviation that is referenced to geographic north. |
| **True North** | Geographic north. |
| **UHF** | Ultrahigh Frequency. The frequency band between 300 and 3,000 MHz. |
| **VFR** | Visual Flight Rules. Rules that govern the procedures for conducting flight under visual conditions. |
| **VHF** | Very High Frequency. The frequency band between 30 and 300 MHz. |
| **VOR** | Very High Frequency Omnidirectional Range Station. A ground-based electronic navigation aid transmitting very high frequency navigation signals, 360 degrees in azimuth, oriented from magnetic north. |
| **VORTAC** | A navigation aid providing VOR azimuth, TACAN azimuth, and TACAN distance measuring equipment (DME) at one site. |
| **Vx** | The speed at which the aircraft will produce the most gain in altitude in a given distance (best angle of climb). |
| **Vy** | The speed at which the aircraft will produce the most gain in altitude in the least amount of time (best rate of climb). |
| **WAAS** | Wide Area Augmentation System. Extremely accurate navigation system developed for civil aviation. |
| **Waypoint** | A predetermined geographical position. |

**Day-by-Day Plans**

*Time: 9 days*

**Day 1:**

       The teacher will present **Navigation History.ppt** while students take notes in their journal.

       The teacher will present **Radio Navigation.ppt** while students take notes in their journal.

       Teacher will distribute and explain **Activity 1.3.1 Introduction to Navigation**.

       Students will complete Activity 1.3.1 Introduction to Navigation.

**Day 2-3:**

       The teacher will present **Navigation and Flight Planning.ppt**.

       Teacher will distribute and explain **Activity 1.3.3 Cross Country Solo**.

       Students will complete Activity 1.3.3 Cross Country Solo.

**Day 4:**

       The teacher will present **Air Traffic Control.ppt**.

       The teacher will distribute **Activity 1.3.4 Air Traffic Control**.

       The teacher will show the Kidscontrol video available from the [**NASA ATC Simulator website**](http://www.atcsim.nasa.gov/). Note that the video may be downloaded for more convenient viewing.

       Students will complete Activity 1.3.4 Air Traffic Control.

**Day 5:**

       The teacher will present **GPS Navigation.ppt****.**

       The teacher will distribute the user’s manual and the Garmin eTrex Venture**®** HC GPS Unit.

       The teacher will demonstrate the Garmin eTrex Venture**®** HC interface GPS Unit, procedures, and output interpretation.

       Students will practice using the GPS unit.

**Day 6:**

       The teacher will distribute and explain**Activity 1.3.5 GPS Route Chart Creation** and**Activity 1.3.6 GPS Route Planning**.

       Students will gather the data required for**Activity 1.3.6 GPS Route Planning**.

       The teacher will introduce students to the simulated airspace area and its contents.

        Students will complete Activity 1.3.5 GPS Route Chart Creation.

**Day 7:**

       The teacher will introduce students to flight planning.

       The teacher will distribute Activity 1.3.6 GPS Route Planning.

       Students will take notes and ask questions for clarification.

       Students will complete Activity 1.3.6 GPS Route Planning.

**Day 8-9:**

       The teacher will distribute and explain **Activity 1.3.7 GPS Route Execution**.

       Students will complete **Activity 1.3.7 GPS Route Execution**.

       Students will complete simulated flights using textual and visual GPS information.