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Aerodynamics and Me

Curriculum Unit 90.07.01
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I. INTRODUCTION

The purpose of this unit will be to learn and experience various educational activities through the study of aerodynamics. By having a culminating activity using the information learned during the study of aerodynamics it will be a more meaningful and rewarding experience. Most students do not have a background in aerodynamics and I believe a good introductory activity will be to use the "Car Builder," a scientific simulation that lets students design, construct, refine, and test cars that they build on the computer screen. The initial design will be saved on a computer disk for refinement after completing the unit on aerodynamics.

Ask the students if they have ever thought about why objects are designed in various shapes. If so, list some of the objects they have thought about. This list will lead into the discussion of aerodynamics. We will define the term "aerodynamics" by having the students look up the meaning of "aero" and "dynamics."

aero—air: of the air dynamics—The science dealing with motions produced by given forces. Before we start studying some of the scientific principles about aerodynamics, we will research some of the early contributors to the field of aerodynamics. We will have the students do a short research paper on the Wright Brothers and Samuel Langley. If possible, work with a teacher in the English Department on this project. You might also look at some units done by other teachers to get ideas about available reading materials.

II. METRIC SYSTEM

The metric system of measurement is used in all branches of science and more experiences are needed to become more comfortable and competent with this system of measurement. A good introductory filmstrip is entitled "A HISTORY OF MEASUREMENT" by Learning Resource Company. This filmstrip traces the early standards of measurement and the problems with these standards to the presently accepted standards of the metric system.

We will begin with the measurements of mass (grams or kilograms), volume (liters), length (meters), and time (seconds). After mastering these basic units we will find the density of several objects using the techniques we have used to find and volume.

Mass is the preferred term to use over weight when describing properties of matter as matter can become weightless but it does not become massless.

The balance is the instrument we will use to measure mass in the middle school. The introductory assignment with the measurement of mass should involve a teacher demonstration/explanation on the use of the balance and the introducing of the following terms: gram—beam—adjustment knob—riders—zero point.

After the introductory lesson, a good homework/follow-up activity would be Lab Skill 3 from "Basic Skills in the Laboratory" by Charles E. Towne and published by Cebco Standard Publishing Company, copyright 1977. This exercise gives the student an opportunity to practice reading the position of the riders on the beams before they begin the practical application exercise.

The practical application should begin by giving students objects of known masses to help their confidence with the use of the balance. After this has been completed the massing of some common objects in metric units is also helpful.

A good way to end this section is to give the students 10 marbles and have them find the mass of 1-3-5-7-9 marbles and plot the results on a graph with the number of marbles vs the mass of marbles. They should then use the graph to interpolate the mass of 2-4-6-8-10 marbles. If so desired, the percent of error can be found by comparing the results from the graph against the actual mass of 2-4-6-8-10 marbles and using the following formula:

real mass — estimated mass % error = ——————————————— x 100% real mass Volume will be found by using the graduated cylinder and overflow can. Even though the mathematical procedure is more accurate when used in our laboratory setting, at this point it is more important to introduce new techniques and procedures than to obtain exact answers.

A good homework assignment is Lab Skill 2 in the same "Basic Skills in the Laboratory" by Charles E. Towne. This exercise explains the meniscus and gives examples for reading a meniscus in the graduated cylinder.

Continued use of the marbles for the practical application is advisable for this exercise. When using the graduated cylinder to find the volume of the marbles directly, place a rubber stopper in the bottom of the cylinder to absorb the shock and prevent breakage.

As with finding the mass of marbles repeat the same procedures of finding the volume of 1-3-5-7-9 marbles using the graduated cylinder and graphing the results of volume of marbles vs number of marbles.

Using the graph interpolate the mass of 2-4-6-8-10 marbles. If so desired, again you can find the percent of error by using the same formula as was used for finding percent error with mass.

If you would like them to try finding volume of the cylinder using the mathematical method, a fun exercise is to use a coffee can and the graduated cylinder. Using the formula V = 3.14 x R x R x H they can find the volume and then check their results by using the graduated cylinder and water. If possible, it is best to use a vernier caliper for your measurements.

The measurement of length in meters and centimeters seems to be the most common units used by middle school science students and so the emphasis will be with these units when measuring objects.

After the demonstration/explanation of the meter stick and metric ruler is completed a good follow up exercise is Lab Skill 1 in Basic Skills in the Laboratory” by Charles E. Towne.

Students should then be allowed to measure various common objects to become more familiar with their dimensions in metric units. Estimating sizes and distances is also a good activity and finding their percent error always adds to the fun.

Other activities could be to find their pace (amount of steps to cover 10 meters) and find distances to various places using their pace. If possible, the actual distance could be found and the percent error calculated. Having the students measure themselves on the wall in metric units and comparing their differences in height and also finding the average height for boys, girls, and the class can help them to relate to metric units.

Another activity could be the use of the triangulation method to find the distance to an unknown object. Again the actual distance could be found and the percent of error calculated.

If you have access to vernier calipers, students enjoy working with these as their measurements are more accurate and they are learning to use a new instrument. A good source of information for the use of the caliper is “Selected Experiments for Elements of Physics” by Buchanan and Murphy. This text can be probably be found at the SCSU bookstore as this was written for their physics course.

Although we use the same units of time in both the english and metric system, we should spend time understanding some time intervals such as the second, minute, and then larger units for describing various events in earth history.

A good textbook for this is “Interaction of Earth and Time” published by Rand McNally & Co. 1972.

This text begins with the students estimating various time intervals without any method of counting and then gives them a method of counting to become more accurate with their estimation of time.

The unit also has an activity that will help them to better understand the vastness of time and time intervals between various events in earth history by constructing a time line on adding machine tape. This allows the student to visually see the distances between the lines which represent events that have happened since the origin of the earth.

The finding of density is a good way to tie up this section on the metric system as we have to find the mass and the volume in order to find an object’s density.

A suggested way to start this topic is to have the student find the density of one rubber stopper and then the density of two rubber stoppers. We can again use our graphs on the volume and mass of marbles to figure out the density of glass. This exercise impresses the fact that the amount of the same type of matter does not affect the density of an object and can be used to distinguish similar looking objects from one another.

The evaluation of this topic can be the finding of density of some objects such as brass, copper, lead, and aluminum. After determining their densities, construct a bar graph to visualize their differences.

We are now ready to study the atmosphere to prepare for our study of aerodynamics.

III. THE ATMOSPHERE

The atmosphere is the mixture of gases that surround the earth and are held here by the force of gravity. There are several layers of the atmosphere which are separated by differences in temperature. As airplanes fly only in the troposphere and stratosphere we will concern ourselves with these two layers only. The troposphere is the layer of the atmosphere that we live in. Most of the air is nitrogen (78%) and oxygen. (21%) This dilution of nitrogen is very important as oxidation would take place much more rapidly probably causing more damage by fires and rusting than we now experience.

Oxygen is very flammable and a good way to show this property is to do an electrolysis of water experiment. Use an inverted test tube to collect the gases hydrogen and oxygen then test each with a glowing splint placed at the mouth of the test tube to observe the reaction. The oxygen in the air is necessary for the combustion of the fuel in airplane engines to operate in the atmosphere.

Air like water is a fluid and has similar characteristics. One is that it exerts pressure in all directions and pressure increases with depth. A good way to show this is to place a piece of rubber over a thistle tube and connect it to a u-shaped piece of glass containing colored water with rubber tubing. Submerge the tube in water and have the students observe what happens to the water level in the u-shaped tube. After completing this exercise ask the students what they think will happen when you rotate the thistle tube in the water but keep the mouth at the same depth. This exercise will help the student to remember that air pressure decreases as you ascend and that it is exerted equally in all directions. You might also ask them what happens to them when they try to reach the bottom of a swimming pool. This will also lead to a discussion of flight suits, diving suits, and pressurized cabins.

Some jet planes fly in the lower layer of the stratosphere and so this can lead to a discussion about solar flares and other sources of radiation plus the ozone layer which protects us from harmful ultraviolet radiation from the sun.

IV. THE AIRPLANE AND FLIGHT

To understand flight, we must first understand three basic things about airplanes.

1. The major parts and the function of each of these parts.
2. The forces that act on the aircraft.
3. How to control the aircraft.

A. THE MAJOR PARTS OF OF THE AIRPLANE

The airplane is divided into 5 major parts.

1. fuselage
2. wing
3. engine
4. tail section
5. landing gear

Fig. 4-1.

(figure available in print form)

Fig. 4-2.

(figure available in print form)

Fig. 4-3.

(figure available in print form)

Fig. 4-4.

(figure available in print form)

Fig. 4-5.

(figure available in print form)

The fuselage contains the cockpit and flight controls, the passenger compartment, and all major parts of the airplane are connected to the fuselage.

The wings are the devices that provide lift for the airplane and contain the ailerons which are used to change the direction of flight. Wings come in various shapes and sizes.

The engine is the vehicle that provides the thrust for the airplane. The engine can be propeller driven, a device that bites into the air causing the plane to thrust forward, or jet powered, compresses air and forces it out the rear opening at a higher rate of speed.

The tail section gives the airplane directional stability by the vertical stabilizer, (rudder) and the horizontal stabilizer. (elevators)

The landing gear is important not only for landing the aircraft safely, but also to get the aircraft into the air. The landing gear can be fixed in place or it may be retractable into the fuselage. In most cases, the retractable is more desirable as it reduces drag on the airplane and is less likely to be exposed to hazards in flight. The flaps, which are located on the wings, also aid the aircraft in landings and take-offs.

B. FORCES ACTING ON THE AIRPLANE IN FLIGHT

There are four major forces acting on an airplane in level flight at constant speed. They are lift, gravity, thrust, and drag.

Fig. 4-6.

(figure available in print form)

In order to lift the airplane into the air, we must overcome the force of gravity. This is accomplished by having the wing shaped in such a way that a low pressure area is created at the top of the wing by air moving faster over the top than across the bottom of the wing. This unequal pressure causes the wing to move up to fill this area of lower pressure. The angle of the wing and speed of moving air will determine the amount of lift.

Near the end of a class period have the students blow across a piece of paper and have them observe what happens to the piece of paper. Do not say anything at this time. Ask if anyone would like to blow a ping-pong ball out of an upright funnel. After trying to do this tell them you will help them out by inverting the funnel and again ask for volunteers. Upon completing this activity have them do a homework assignment on “Bernoulli Principle.” Discuss this principle the next day and how it relates to an airplane. Explain that some books try to use this as an explanation for flight but, this does not explain flight otherwise how could an airplane fly upside down? Briefly explain that it is a circulation pattern around the wing that causes lift. A good explanation can be found in “What Makes Airplanes Fly.”

Gravity is the force that tends to pull all matter toward the center of the earth. This force must be overcome before the aircraft can become airborne. An aerodynamically designed craft will make this task a little easier.

Thrust is what causes an airplane to move forward. The faster the engine causes air to move, the faster the aircraft will travel.

Drag is the opposite of thrust and is caused by the resistance of the airplane. Again aerodynamics plays an important part in reducing drag by streamlining the airplane to let the plane operate more efficiently.

Newton’s Laws can be discussed at this time and explained how they relate to flight. A good way to start the discussions is to use a ballistics car. Start by showing what happens to the ball when the car is at rest. Now put the car into motion and observe what happens to the ball. Ask how many students have ever heard of Sir Isaac Newton. Have them do a homework assignment on Newton telling where he lived, when he lived, and a brief explanation of his three laws.

Discussion of this assignment could begin with defining “inertia.” Discuss what value seat belts are to people in automobiles by talking about what forces act on a person in the car from starting to moving to stopping and running into a tree.

We could discuss why the more massive a plane the more fuel it will use to operate. $F = ma$

Blow up a balloon and let it go. Ask students why the balloon behaved as it did. Newton’s action—reaction

If you have access to Physical Science Software by Prentice-Hall you will find the following disks very helpful.

NEWTON’S FIRST LAW

Students begin by seeing examples that illustrate the law of inertia. Then they examine forces that affect motion, and control and measure these forces and their effects on the object involved. Such interaction allow for an understanding of motion in terms of analysis of position and velocity. Finally, students analyze and apply Newton’s First Law.

NEWTON’S SECOND LAW

In this product, students explore the mathematical relationship between force, mass, and acceleration. By analyzing and measuring velocity and acceleration, they discover how various quantities in Newton’s Second Law of Motion are affected when the values of this other quantities are changed. Students also carry out rearrangement of the equation. By doing so, they learn how to handle the units involved in the expression of force, mass, and acceleration.

NEWTON'S THIRD LAW

After students generate, monitor and measure action and reaction forces, they compare the magnitudes of the forces and motions involved and investigate net force. They then discover the relationship between the mass-velocity products of two objects that are acting upon one another. In this way they discover the nature of momentum and the role of this quantity in action-reaction situations.

C. CONTROL OF THE AIRPLANE

The control surfaces of an airplane are found on the wings, horizontal stabilizer, and vertical stabilizer. These control surfaces control the three axes of movement. Pitch, roll, and yaw.

Fig. 4-7.

(figure available in print form)

Pitch is the rise and fall of the airplane. The elevators on the horizontal stabilizer will control this movement. A fun activity is to have the student make a paper airplane to test how the elevators control the rise and fall of an airplane.

Fig. 4-8.

(figure available in print form)

The roll of an airplane is controlled by the ailerons. These work opposite each other meaning when one aileron is in the up position the other is in the down position which causes the airplane to roll left or right depending on which is up or down position.

The yaw of the airplane, side to side motion, is controlled by the rudder which is located on the vertical stabilizer. This is used to make minor adjustments as "skidding" takes place if major adjustments are to be made so the use of the ailerons are more effective.

Now that we know how to get the airplane into the air and we are able to control the flight path so that we can go where we wish to travel, what else should we know?

V. NAVIGATION

We must learn how to navigate the airplane. In order to do this, we must know the starting point, the distance to be traveled, and the direction to be traveled. This is know as "dead reckoning." A chart, pilots map, is used to set up the airways a pilot must follow to get to his destination. A compass rose is used to plot headings and the course line to be followed.

Fig. 5-1.

(figure available in print form)

The distance to be traveled is figured mathematically by multiplication. Air speed times time traveled = distance traveled.

We can introduce the formula distance = velocity times time and have some fun determining different factors of a flight. We use the term velocity instead of speed as we must know the direction we are traveling as well as the speed when we are dealing with navigation.

If you have access to the Science Toolkit-Speed and Motion, this will allow the student to do actual measurements with a balloon car.

Let us now look at how aviation influences our environment.

VI. AVIATION AND THE ENVIRONMENT

Many of us do not realize the full impact that aviation has made on our lives. There are over 4,000 public airports in the United States and 90% of the population of the United States live within one hour of a public airport. Not only has it made travel and trade between countries possible, it has made an important impact on local communities. It has helped the local economy by providing jobs, made travel to work less stressful by giving up to the minute traffic reports, helping with wildlife management, aerial mapping of areas, preventing destruction of property and saving time, and many more. There are of course some negatives such as noise pollution to prevent some areas from expanding existing airports or trying to obtain an airport for their community.

Each individual must make his own decision on the values of the airplane. I believe most will think of it as a valuable invention and will use this invention to their advantage whenever possible.

VII. BIBLIOGRAPHY

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“WHAT MAKES AIRPLANES FLY?”

SPRINGER VERLAG NEW YORK INC., (IN PRESS) 1990

MODERN PHYSICAL SCIENCE

TRACY-TROPP-FRIEDL.

HOLT, RINEHART, AND WINSTON, INC. COPYRIGHT 1974

PHYSICAL SCIENCE

THE CHALLENGE OF DISCOVERY CARLE-SARQUIS-NOLAN

HEATH

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COMPUTER SOFTWARE

PRINCIPLES OF FLIGHT—DISK 1-2-3

NASA

AVIATION AND OUR ENVIRONMENT—DISK 1-2-3

NASA

SCIENCE TOOLKIT—SPEED AND MOTION

BRODERBUND

CARBUILDER

WEEKLY READER FAMILY SOFTWARE

AERODYNAMICS: WHAT A DRAG!

GENERAL MOTORS

LESSON PLAN

Purpose TO FIGURE PROBLEMS OF NAVIGATION USING THE FORMULA

D

V = Đ Đ

T

Goal UPON COMPLETION OF THE LESSON, THE STUDENT WILL BE ABLE TO DETERMINE THE SPEED, DISTANCE, OR TIME WHEN GIVEN TWO OF THE FACTORS.

Procedure EXPLANATION/DEMONSTRATION: WHERE V = VELOCITY (Km/hr),

D = DISTANCE (Km), AND T = TIME (HR).

D

THE FORMULA V = —
T

THE FORMULA D = VXT

D

THE FORMULA T = —
V

Practical Application

1. YOU ARE FLYING AN AIRPLANE IN A NE DIRECTION AT A SPEED OF 1000Km/hr, HOW FAR WILL YOU TRAVEL IN 2.5 HOURS?
2. HOW LONG WILL IT TAKE YOU TO TRAVEL 2000 Km AT A SPEED OF 80 Km/hr?
3. HOW FAST DID AN AIRPLANE TRAVEL TO GO 1500 Km IN 3 HOURS?

Evaluation MAKE UP SIMILAR PROBLEMS, TWO EACH, FOR TESTING PURPOSES.

LESSON 2

Purpose TO FIGURE THE DISTANCE, DIRECTION, AND APPROXIMATE TRAVEL TIME TO A DESTINATION USING A COMPASS ROSE.

Goal UPON COMPLETION OF THIS LESSON THE STUDENT WILL BE ABLE TO USE A COMPASS ROSE EFFECTIVELY TO TELL DIRECTIONS, DETERMINE DISTANCES BETWEEN POINTS WHEN GIVEN A MAP SCALE, AND ESTIMATE TRAVEL TIME WHEN GIVEN THE VELOCITY OF THE AIRCRAFT.

Procedures EXPLANATION/DEMONSTRATION

1. THE COMPASS ROSE.
2. REVIEW METRIC RULER. (CENTIMETERS)
3. MAP READING USING MAP SCALES FOR DISTANCES.

4. REVIEW FORMULA—$T = \frac{D}{V}$

Practical Application SEE NEXT PAGE.

Evaluation MAKE UP TWO PROBLEMS SIMILAR TO THE PRACTICAL APPLICATION.

PRACTICAL APPLICATION

(figure available in print form)

1. WHAT DIRECTION WILL WE TRAVEL TO GET FROM POINT A TO POINT B?
2. USING THE SCALE OF 1 CM = 1,000 KM, HOW FAR IS IT FROM POINT A TO POINT B?

3. TRAVELING AT 1,000 KM/HR, HOW LONG WILL IT TAKE TO TRAVEL FROM POINT A TO POINT B?