"Air and Aerodynamics"
-What do I need to know???

Throughout this unit we will be doing science experiments, class discussions, and activities. This is one of our big science units in grade 6. To help keep you organize here is a list of things that you will need to know in order to meet the learning expectations.

- Explain that air takes up space and puts pressure on things, give examples of this being proven
- Provide evidence that shows that air is a fluid and can be compressed
- Describe and demonstrate times when air movement can create lift (Bernoulli's Principle)
- Be able to draw and label diagrams that would help someone understand Bernoulli's Principle
- Understand that things and animals must have lift in order to overcome gravity so they can achieve flight
- Explain adaptations that allow birds and insects to fly
- Describe **propulsion** for flying animals and aircraft
- Understand that **streamlining** reduces **drag**
- Predict the effects of changing specific design components on an airplane
- Describe what air is made of and describe ways that we can prove that certain gases are in the air

Vocabulary

Aerodynamics
Air
Airfoil
Air pressure
Bernoulli's Principle
Mass
Oxidation
Rusting
Thrust
Compression
Drag
Expand
Glider
Lift
Propeller
Resistance
Streamlining
Weight

Science Mark:
60% daily work 30% quizzes, tests 10% project

NAME: _____

- Glossary -

Aerodynamics: The science of moving through air.

Air: An invisible mixture of gases which make up the Earth's atmosphere - it consists mainly of nitrogen and oxygen.

Airfoil: A shape designed to provide lift when air flows around it.

Air pressure: The force exerted on the surface of objects by the weight of air particles - air pressure acts from all directions and increases with increased concentration of air molecules.

Air resistance: Resistance or friction that acts to slow down and object as it moves through air.

Atmosphere: The mass of air which surrounds the earth.

Barbules: Projections on barbs that link with those above and below them to keep all the barbs connected making a solid feather surface.

Bernoulli's principle: When the speed of a fluid is low (water or air), the pressure is high. When the speed of a fluid is high the pressure is low. The faster that air moves across a surface, the lower the air pressure.

Burning: A rapid form of oxidation in which substances combine with oxygen to form one or more oxides and plenty of heat and light, also called **combustion.**

Compression: The squeezing of the particles of a gas or porous body into a smaller space.

Contour feathers: The larger feathers that cover the body of birds and their wings. Contour feathers include flight feathers.

Down: Short fluffy feathers that lie underneath contour feathers. These feathers trap air and act as an insulator helping birds stay warm.

Drag: Resistance or friction that acts to slow down an object as it moves through a gas or liquid.

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Expand:	To take up more room.
Friction:	The force that resists motion of one body over or through another.
Glider:	A aircraft that flies without an engine - its pilot tries to find updrafts of air to gain height and extend the flight.
Gravity:	A force of attraction that every mass in the universe exerts on other masses. This force increases with increase in mass of an object.
Hovercraft:	A machine that floats on a cushion of compressed air.
Jet engine:	An engine that generates a powerful thrust in a chamber where the explosion of the burning fuel pushes on the airplane in a forward direction but escapes out the back.
Keratin:	A tough flexible protein that makes up fingernails and other parts of animals including the shaft of feathers.
Kinetic energy:	Energy of motion. The faster an object moves the more kinetic energy it has.
Lift:	Upward force which acts against the force of gravity - reducing air pressure on the top side of an airfoil produces lift.
Mass:	The amount of matter in an object
Pectoral muscles:	Muscles of the chest.
Preening:	The act of rubbing preen gland oil on the feathers with the beak and zipping up the barbules again.
Propeller:	Curved blade that, when spun around quickly, forces an aircraft forward - a propeller is a twisted airfoil.
Oxidation:	Occurs when a substance combines with oxygen.
Resistance:	Drag or friction that acts to slow down an object as it moves through a gas or liquid.

Rusting:	A slow chemical reaction between iron and oxygen to form rust or iron oxide.
Streamlining:	The shaping of an object so that a gas or liquid will move easily around it.
Thrust:	The force that causes an object to move forward.
Weight:	The force with which gravity pulls on an object - technically it should be expressed in Newtons but is often measured in units of mass such as grams or kilograms.

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Air and Aerodynamics Notes

Air

- Air is the mixture of gases that surrounds the earth
- It is often called the atmosphere.
- Air covers the land and sea and extends far above the earth's surface.
- We cannot see, smell, or taste air.
- Without air, there would be no life on earth.
- A person can live more than a month without food or water but only minutes without air.

What does Air do?

- Air does much more than make it possible for us to breath.
- Air shields the earth from certain harmful rays from the sun and other objects in outer space.
- It traps the heat that comes from the sun, therefore helping the earth warm enough to support life.
- Air protects us from meteors, most of which burn up in the atmosphere.
- Clouds that form in the air bring us water in the form of rain or snow.
- Air also helps us hear. Sound must travel through the air or some other substance.
- Air moving past the wings of a plane enables the plane to fly.

What is Air?

- Air consists of a mixture of gases that extends from the earth's surface to outer space.
- The earth's gravity holds the air in place around the earth.
- The gases of the air move about freely among one another.

Gases of the Air

- The principal gases of the air are nitrogen and oxygen. Other gases include argon, water vapor, carbon dioxide, neon, helium, krypton, hydrogen, xenon, and ozone.

- Nitrogen = 78%
- Oxygen = 21%
- The remaining 1 % consists mainly of argon with only extremely small amounts of the other gases.
- Some gases in the air are extremely important.
- When we breathe air we take in oxygen from the air and give off carbon dioxide.
- Oxygen from the air plays a part in such chemical processes as the rusting of iron and the formation of vinegar from cider.
- Water vapor and carbon dioxide in the air help keep the earth warm.
- They prevent some of the surface heat created by sunlight from escaping back into space.

Moisture in the Air

- Comes from water vapor.
- Water vapor enters the atmosphere when water evaporates from oceans, lakes, rivers and moist soil.
- The more moisture there is in the air the higher the humidity.
- If the air becomes cold enough, the water vapor begins to change to tiny water droplets or ice crystals. This process is called condensation.
- As air rises, the temperature decreases. Cloud form when large masses of moist air rise and are cooled below the dew point.

Particles in Air

- Air always contains many tiny solid particles called aerosols.
- They are invisible, except when crowded together in extremely large numbers.

How Air Behaves

Weight and Pressure

- We do not usually notice the weight of air because air is much lighter than solids or liquids. However, there are ways has weight with a simple experiment.
- First, we remove the air from a bottle by means of a small vacuum pump. We then seal the bottle and weigh it. Next, we break the seal

so that air rushes into the bottle. When we weigh the bottle again, it weighs more. The added weight is air.

- An instrument called a barometer is used to measure air pressure. Barometers indicate air pressure in inches or millimeter or mercury or in units called bars and millibars.
- We use air pressure as a force in various ways. When we suck a soft drink through a straw, for example, we do not actually pull the liquid up through the straw. Instead, by sucking on the straw, we remove some the air from inside it. As a result, the air pressure inside the straw becomes less than the pressure of the air on the liquid outside the straw.
- The greater the pressure of the air outside then pushes the liquid in the glass up through the straw and into our mouths.

Air Movement

- Air moves across the surface of the earth in the form of wind.
- Bands of fast moving winds occur about 6 to 9 miles above the earth. These bands are known as jet streams.

Air Resistance

- Air resists the motion of objects traveling through it. This resistance occurs because moving objects rub against the atoms and molecules of the gases that make up the air.
- The faster objects move through the air, the more resistance they meet. For example, the faster you ride a bicycle, the stronger the air resistance against you will be. As you increase your speed, you can feel the air pushing harder and harder against you.

Air Compression

- Air can be pumped into steel cylinders or tanks until the air pressure is several hundred times greater than normal atmospheric pressure.
- Such air is called compressed air.
- When air is being compressed, the atoms and molecules of the air speed up. As their speed increases, the air gets warmer.
- People use compressed air to inflate tires and air mattresses.

Aerodynamics

- Is the study of the forces acting on an object as it moves through air or some other fluid.
- Aerodynamics forces act on airplanes, sailboats, and any other object moving through the air.
- The Wright brothers studied aerodynamics before they succeeded in building the first successful airplane.
- Some kinds of flight do not involve aerodynamics. A spacecraft flying through space does not involve aerodynamics because there is no air to produce aerodynamic forces.

Principles of Aerodynamics

- Most aerodynamic principles relate to the two basic aerodynamic forces – lift and drag.

Lift

- Is an aerodynamic force produced by the motion of an airfoil (wing) through the air.
- The lift force acts at a right angle to the direction of motion.
- Lift gives an airplane the ability to climb into the air and hold it up during flight.
- An airfoil moving through the air produces lift because it has a greater pressure on its lower surface than on it supper surface.
- According to a principle discovered by Daniel Bernoulli, a Swiss mathematician, the pressure of a fluid decreases as its speed increases – Bernoulli's Principle.
- A typical airfoil has a rounded leading (front) edge and a sharp trailing (rear) edge.
- As the flow of air approaches the leading edge, it splits to go around the airfoil.
- To produce lift, the flows along the upper surface and the lower surface must be unsymmetrical.
- The curved shape of the airfoil, called he camber, can create an unsymmetrical flow.

- The two flows must merge smoothly as they leave the trailing edge – this is called the Kutta Condition.
- The Kutta condition produces a faster flow of along the upper surface thus reducing the air pressure on that surface. As a result, the airfoil is lifted.
- The lift produced depends on the wing's speed through the air. If the wing does not move fast enough, the different in pressure above and below the wing will not produce enough lift to keep the plane in the air.

Drag

- Is an aerodynamic force that resists the forward motion of an object. The shape of the object influences the amount of drag.
- Objects shaped to produce as little drag as possible are called ***streamlined*** or ***aerodynamically clean.***
- Aircraft designers build planes to reduce drag to a minimum.
- Planes with low drag need less engine power to fly, and reduced drag also improves a plane's performance.

Flight of Birds and Insects

- For birds and insects to fly they must create lift.
- They must also produce enough thrust to create propulsion.
- Thrust is the act of an object moving forward and propulsion is what gives the object the force to move forward.
- Thrust and propulsion for flying animals is generated by flapping their wings and creating lift.

Adaptations for Flight

- An adaptation is something such as a device or mechanism that changes so as to become suitable to a new situation.
- A number of adaptations combine to enable birds and insects to fly.
- Except for some birds, such as, penguins, emus, ostriches, most bird species are expertly designed for flight.
- Birds have special adaptations to achieve flight.
- Some adaptations that bird have for flight are:
    - Feathers – create smooth streamlined shape

- Powerful flight muscles - designed to be strong to provide sufficient power for flight. The muscles for both wings and the legs are designed so they do not tire quickly.
- Air sacs
- Hollow bones - help reduce their weight and allow them to keep a large supply of air in their lungs.
- Wings - shape allows them to achieve lift. The wings are curved on top and flat on the bottom. As the bird flaps its wings, air travels over the top feathers and creates a difference in pressure; lift and thrust are achieved on the downward stroke.

- Insect wings are made up of a thing membrane supported by blood filled veins.
- Most insects rely on two pairs of wings, which join or overlap so they work together as a single pair.
- Insect wings are one of nature's lightest structures, lacking bone and muscle.
- They're made of chitin, an extremely tough material that also composes and insect's hard outer skin.
- Insect wings are curved on top and flat on the bottom.
- Air rushing over the wing has to travel further because of the curvature, so this air moves faster than air below the wing.
- Since fast-moving air exerts less pressure than slow-moving air, the difference creates lift.
- Each downward wing flap creates more lift, propelling the creature up and forward.
- Large-bodied insects lift off by flapping their wings rapidly.
- Insect wings don't just flap up and down, on the upstroke insect wings move in a figure-eight motion.
- As the insect wing nears the end of a forward stroke, the wing rotates backwards, twisting upside down, parallel to the ground. This rotation speeds up the flow of air over the wing.
- Insects also have specially designed flight muscles to power their wings.
- Insects are warm blooded.
- This means they have to be warm before their muscles will work. As it gets cold outside insects aren't able to keep their flight muscles warn so they are unable to fly.

History of Aerodynamics

- ✓ Leonardo da Vinci, was the first person to study the flight of birds scientifically.
- ✓ 1600's, the English scientist Sir Isaac Newton set forth a basic theory of air resistance. He explained the behavior of forces acting between an object and a fluid such as air.
- ✓ Mid-1800s, people first used aerodynamic principles in flight.
- ✓ Orville and Wilbur Wright – devoted three years of research to the development of the propeller-driven plane that they flew in 1903.

Aerodynamics Today

- ✓ The use of airplanes during World War I and World War II led to extensive research in the field of aerodynamics.
- ✓ After the development of jet planes in the 1940's, engineers studied supersonic flight.
- ✓ 1950's - airplane designers developed dagger-like noses and swept back wings to reduce drag.
- ✓ 1960's - engineers introduced wings that could be moved into a straighter or swept back position during flight.
- ✓ 1980's - the United States began testing the X-29, an experimental plan with swept-forward wings.

Careers In Aerodynamics

- ✓ Most engineers and scientists who specialize in aerodynamics work for companies that manufacture aircraft, boats, or engines, or for government services.
- ✓ Federal Agencies that employ many aerodynamics engineers include the National Aeronautics and Space Administration (NASA), the Federal Aviation Administration and the Department of Defence.

Name: _____ **Master #1**

Date: _____

Mystery Bag

Sense:	*Observations:*
See	
Hear	
Feel	
Smell	
Taste	

- Is there a substance in the bag? Why or why not?

_____

_____

- Name the substance. _____
- Which sense was most useful in investigating the properties of the substance that was in the bag? Why?

_____

_____

Master #2

Name: _____

Date: _____

Air is Everywhere

Part A

Diagram	Prediction *(What do you think will happen?)*	Observation *(What did happen?)*	Inference *(Why did this happen?)*
(Draw and label)			

Part B

Diagram	Prediction *(What do you think will happen?)*	Observation *(What did happen?)*	Inference *(Why did this happen?)*
(Draw and label)			

Task: **Where's The Pressure?**

Name: _____

Date: _____

Your younger brother now believes that air exists even though he cannot see it. But now he has asked you what air does. Explain how air is working in each of these situations.

1. Two holes are needed to pour juice from a juice can.

2. Water does not run out of an eyedropper unless the rubber end is squeezed.

3. Car doors are harder to close when all of the windows are shut than when one of the windows is open.

4. It is difficult to drink liquid through a straw that has holes in it.

16

Name: _____

Master #4

Date: _____

The Great Squirt Challenge

The Great Squirt squirted _____ cm.
The Great Squirt works because:

Possible ways of making the Great Squirt shoot farther:

-
-
-
-

Select **one** of the variables and write a testable question for this investigation.

Testable question:

_____

_____

_____

Prediction and Hypothesis (I think . . . because . . .):

_____

_____

_____

_____

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Materials:

Procedure:

We will change this condition: • ***MANIPULATED VARIABLE***	
We will keep these conditions the same: • ***CONSTANT VARIABLES***	
We will measure: • ***RESPONDING VARIABLE***	

Observations:

Inferences:

Task: **Balloon Rockets**

Name: _____

Date: _____

Challenge: **Make your rocket go faster and farther than its first flight.**

Materials:

- string
- heavy thread
- fishing line
- various sizes and shapes of balloons
- straws of different diameters
- masking tape
- clear tape
- stopwatches
- Vaseline
- metre sticks

1. Question: _____

2 Hypothesis: _____

3. Procedure: _____

4. Manipulated Variable: _____

_____

5. Responding Variable: _____

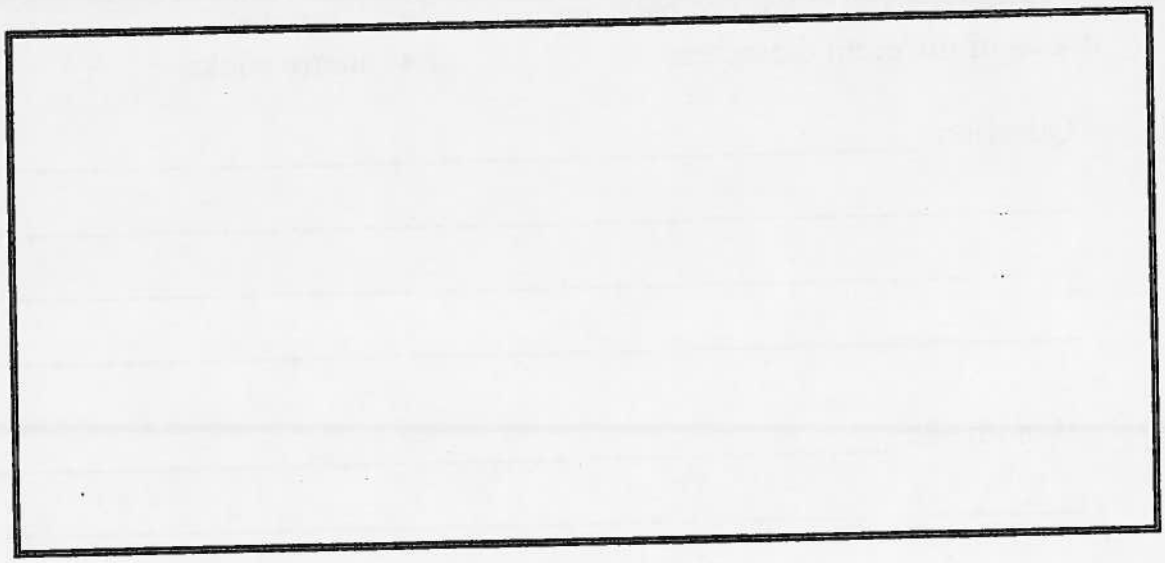
_____

6. Constant Variables: _____

_____

_____

7. Observations:



8. Inference: _____

_____

_____

_____

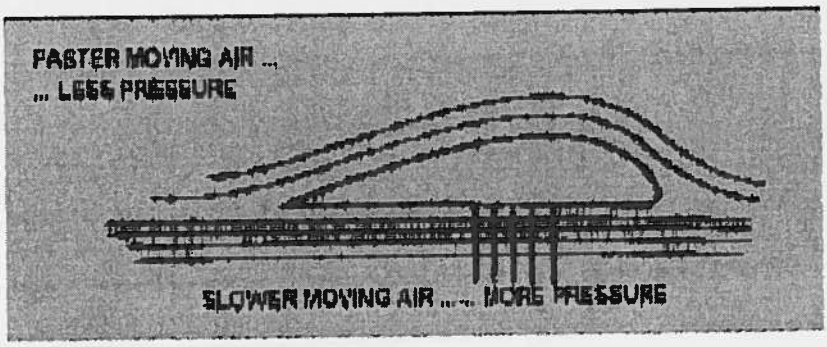
9. What modifications would you make to further improve the flight of your rocket?

10. How is the balloon rocket similar to a real flying device (airplane or spacecraft)?

Bernoulli's Principle

Daniel Bernoulli was a Swiss scientist of the 18th century. His experiments with water flowing through pipes showed that as the **speed of the water increased the water pressure decreased.** Other experiments that he preformed showed that this was true for ALL liquid and gases. **Bernoulli's Principle states that as the speed of a moving liquid increase, the pressure around that liquid decreases.**

Bernoulli's Principle was a key idea in the development of human flight. Aircraft wings are designed so that air flows over the top of the wing faster than it flows underthe wing. This causes the air pressure on top of the wing to be lower. The comparatively higher air pressure underneath the wing pushes the airplanes up and lift is created. **Lift is an upward force that acts against the force of gravity.**

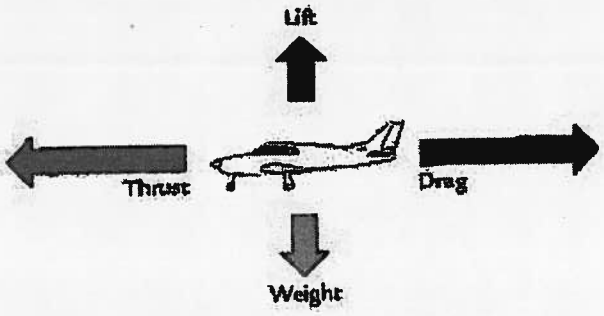


Flight

For aircraft to achieve lift the forces of flight MUST be balanced. There are four forces of flight at work when an airplane flies: **thrust, drag, lift and gravity**.

Thrust- gives the airplane forward motion. It is the force that overcomes drag.

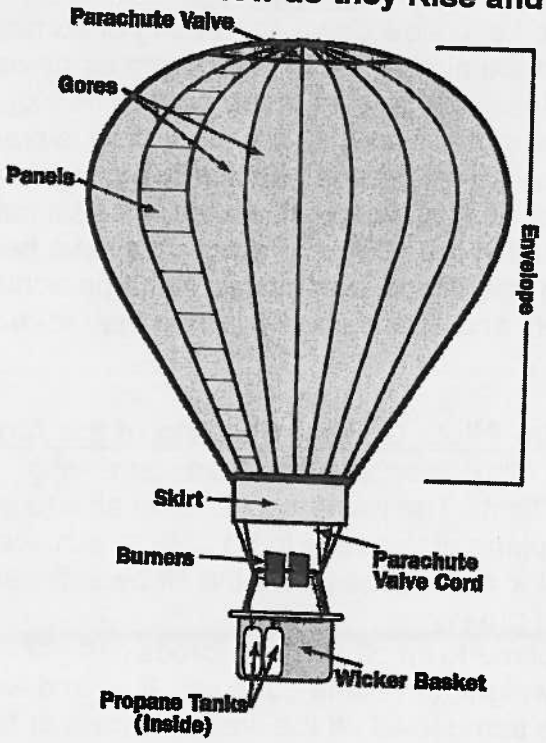
Drag- is the force that acts to slow down an object as it moves through a gas or a liquid. The larger the object, or surface area of an object, the more drag the object has. Today many manufactures design objects with smooth, streamline shapes to overcome the force of drag.



Lift- is an upward force that must overcome the force of gravity.

Gravity- is the force that pulls objects towards Earth.

Hot Air Balloons- How do they Rise and Fall?



Hot air balloons are based on the fact that **warmer air rises in cool air.** A hot- air balloon rises because it is filled with hot, less dense air and is surrounded by colder, denser air. To keep the balloon raising you need to first heat the air inside of it and then you need a way to reheat the air. Hot air balloons do this with a **burner** positioned under the opening of the **envelope.** As the air cools, the pilot can reheat it by lighting the burner.

To lift the balloon, the pilot moves a control that opens up the propane valve. This lever works just like the knobs on a gas grill or stove; as you turn it, the flow of gas increase, so the flame grows in size. The pilot can increase speed by blasting a larger flame to heat the air more quickly. Hot air balloons also have a cord to open up a flap at the top of the envelope that lets air out. When the pilot pulls the cord, some of the warm air escapes out of the top flap. This causes the balloon to **descend** (go down).

To move in a particular direction, a pilot ascends (goes up) and descends to the appropriate level, and rides with the wind. Since wind speed generally increases, as you get higher in the atmosphere, pilots can also control speed by changing altitudes.

Parachutes

A parachute works to slow down something or someone from falling by creating *drag*. Drag is the push on something from air or water. Because air is thinner than water it does not have as much drag. The bigger something is, meaning the larger the surface area is, the more drag is creates. That's why a parachute works so well- it's light and has a very big surface area. It catches lots of air in it creating a lot of drag, which slows it down as it falls. The first real parachute was invented in the 1980's. Parachutes have been used to slow down the descent of people and things ever since. Huge parachutes are used to slow down the fall of rockets and space shuttles when they re- enter the Earth's atmosphere.

How Do Pilots Control the Path of the Airplane?

There is much more to an airplane than just a wing. The plane needs to be able to control its flight. The plane needs to be able to go up and down, and turn right and left. A plane also needs to be able to achieve thrust. Only if the air flows over the wing at a certain speed will the lift be sufficient enough to overcome the force of gravity.

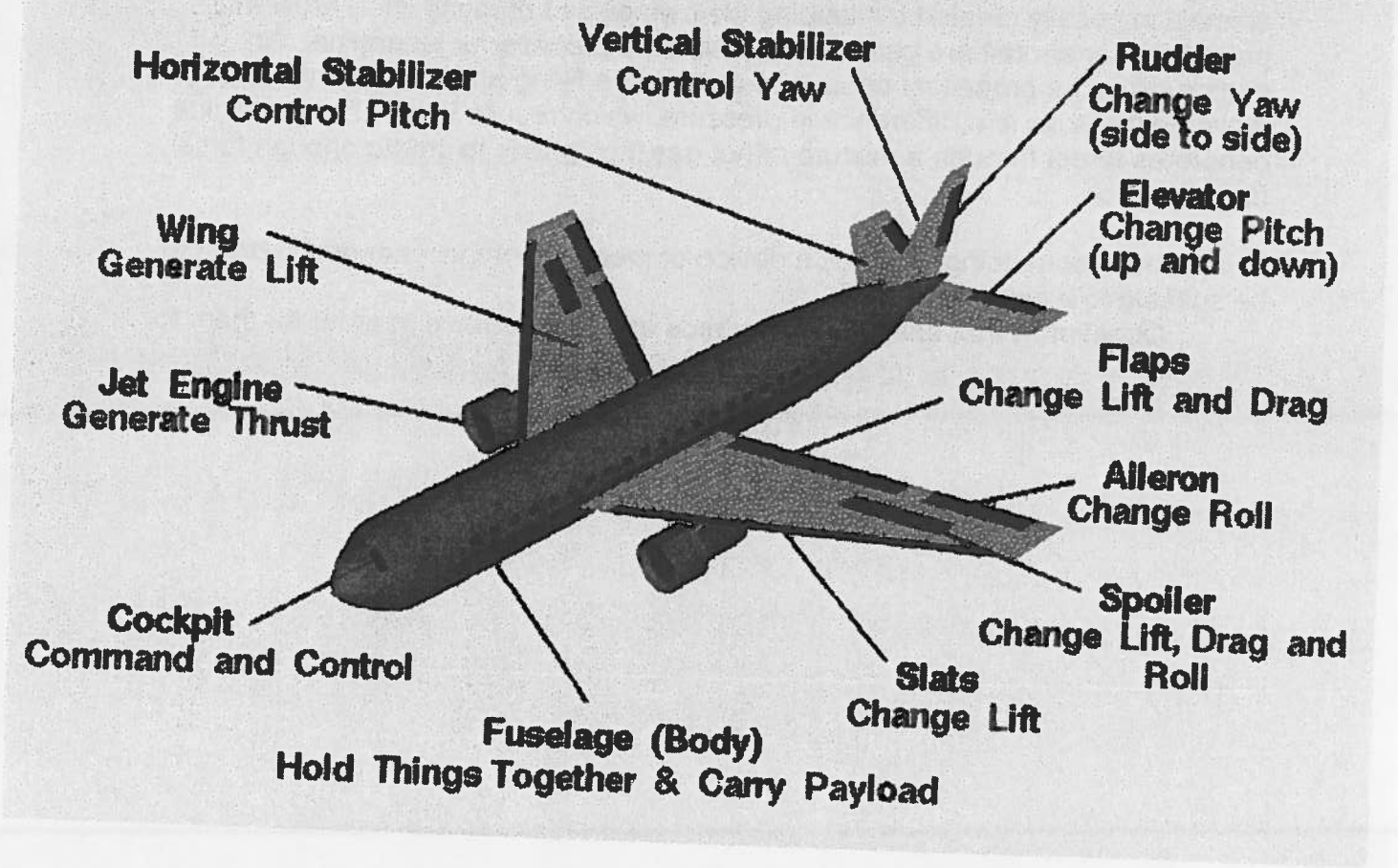
In order for a plane to lift off the four forces of flight must be balanced. If flight is greater than weight, the plane goes up. If lift and weight are equal the aircraft will stay at the same level. If the weight is greater then lift, the plane goes down. The plane must use its engine to move forward. They produce thrust. Thrust is needed to create the speed needed to achieve lift. Acting opposite of thrust is the resistance of air on the plane wing's and body. This is drag. If thrust is greater than drag, the plane moves forward. If the drag is greater than thrust, the plane slows down.

An airplane's engine does not have control over the four forces/ An aircraft is made up of several different parts that enable a pilot to have a successful flight.

- The main body of the plane is called the **fuselage**
- Hinged flaps on the trailing edge of an aircraft's main wing are called **ailerons.** These make the airplane bank left or right, this is called roll. Ailerons control roll. If the left aileron is raised and the left one lowered, this slows the air moving over the uppers surface of the left wing, thereby increasing its air pressure. As a result, the plane banks to the left.
- Two smaller flaps on the plane's tail can be moved up or down. They are called **elevators**. They are attached to the horizontal stabilizers. Elevators control pitch. Remember PITCH is the upward or downward movement of the plane. With the elevators down, lift on the tail is increased and the nose drops. With the elevators up, lift on the nose is increased; the tail goes down and the nose rises.
- The flap attached to the tail of the wing on the vertical stabilizers is called the **rudder**. The rudder allows the planes to change directions. This is called yaw. If the rudder is turned to the left, the nose of the plane turns left. If the rudder is turned to the right, the nosed of the plane turns right. Pilots can use the ailerons and rudders to turn the plane.

Airplane Parts Definitions
and Function

Glenn Research Center



Helicopters

One of the problems with most aircraft is that they are quite large and cannot hover in one place. They have to be moving all the time to achieve lift. This is not the case for helicopters. Helicopters are designed with a giant horizontal propeller know as a rotor that spins around very quickly. Each of the long thin blades is the shape of an airfoil. These blades cut through the air at high speeds and provide the helicopter with lift. Lift can be generated going straight up, hovering, flying forward, or flying backward. To move in these different directions all the pilot has to do is tilt the rotor in the direction the pilot wants to go. The four forces of flight still apply to the movement of a helicopter.

How Do Birds and Insect Fly?

For birds and insects to fly they must create lift. They also must generate enough thrust to create *propulsion*. *Lift* is an upward motion that acts against the force of gravity. *Thrust* is the act of an object moving forward and *propulsion* is what gives the object the force to move forward. Thrust and propulsion for flying animals in usually created by flapping their wings and creating lift. Thrust and propulsion for aircraft are generated by either, a propeller or jet engine. An engine gives the propellers enough force to move flying aircraft forward. The movement results in a difference in pressure, which results in lift. The jet engine generates thrust through a mixture of hot gas that ignites to create enough force for propulsion.

Adaptation- something, such as a device or mechanism that changes in order to be suitable to a new situation.

Question: What adaptations do birds and insects have in order for them to fly?

How are Spacecraft and Aircraft Different?

	Spacecraft	Aircraft
How do they achieve lift?	Since there is no air in space, Bernoulli's Principle does not apply. Spacecraft generate thrust through 2 large rocket boosters, and 3 engines. The engines burn liquid oxygen and hydrogen. The fuel for the engines is stored in a large tank attached to the shuttle. After lift-off, the fuel tank is detached from the shuttles. With the help of a parachute it lands safely in the ocean where it is picked up.	An airplane achieves lift by first generating thrust, which then creates enough speed to achieve lift.
Inside the craft	Spacecrafts are designed to meet the needs of the astronauts. Astronauts need air to breathe, food, water and a warm temperature.	Carries people and cargo.
How do they land?	When the shuttle is ready to come back to Earth it positions itself to come through the earths atmosphere. The shuttle is moving so fast that larger amounts of heat are generated from the friction of air molecules. Spacecraft are designed to be protected from the heat. They have reinforced carbon-carbon on the wings surfaces and underside, high temperature black surface insulation tiles on the upper forward fuselage and around the windows, and low temperature white surface tiles on the remaining areas. When the spacecraft enters the atmospheres the shuttle is able to fly like an airplane.	Position the elevators up so that the tail goes up and the nose goes down
Wings	Spacecraft have wings that can generate lift when needed.	

Task: **Bernoulli**

Name: _____

Date: _____

1. How does *Bernoulli's Principle* help explain the force of lift?

_____

_____

_____

2. Apply what you have learned about this principle to answer each of the following questions.

   a. Two light-weight balls are suspended by thread, as in the diagram below.

What would you expect to happen if you blow air between these two balls? Explain why this would happen.

_____

_____

_____

_____

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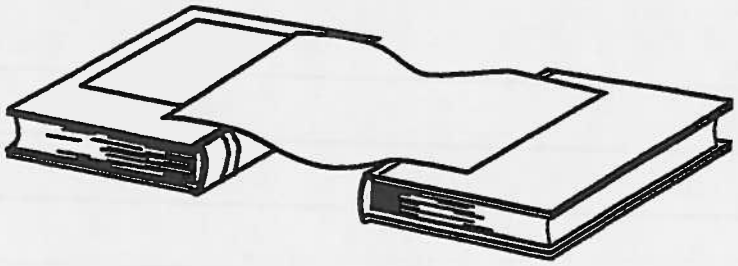
b. To demonstrate the effects of air movement, Peter placed two large books about 10 cm apart on a table. He laid a sheet of paper over the books.



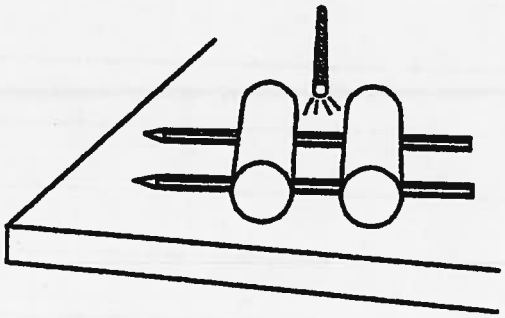
Peter could correctly predict that if he blew underneath the paper it would:

_____

_____

_____

c. Mary placed two pencils on a table about 10 cm apart. She placed two rolls of paper across the pencils, about 3 cm apart. Then she blew between the two tubes with a straw.



Mary predicted that the rolls would move apart. Is Mary's prediction accurate? Why or why not?

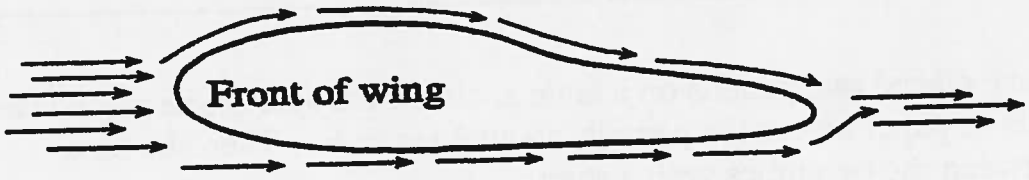
_____

_____

_____

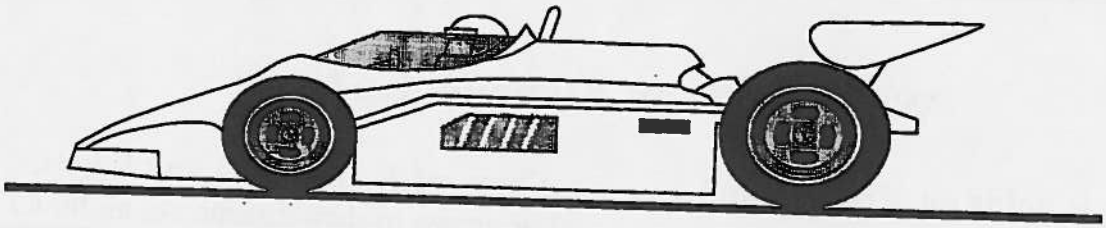
d. You want to demonstrate that air movement can result in lift. What can you do to prove this? Be sure to list the materials you will use and how you will show lift.

3. Air moves over a wing when an airplane is in motion as in the following diagram. Label where the air is moving the *fastest* and *slowest*.



Explain why you labeled your diagram that way.

4. A race car has upside-down wings that create forces on the car when the car is moving fast.



Suggest a reason for having an "upside-down" wing on a race car.

Name: _____

Date: _____

What Holds an Airplane Up?

What holds an airplane up?	Show with diagrams and labels. (Use arrows to show direction of air flow.)
A) An airplane's wings are shaped to make the air flow faster on the upper side than on the lower side. The upper side is curved upward, but the lower side is quite flat.	
B) As the airplane moves, air flows past it. Air slows down when it hits the front of the wing. Some of the air flows along the top part of the wing. Some of it flows along the bottom part of the wing.	

C) The curved top of the wing takes up more space than the bottom of the wing. When the air gets to the wing, it is forced to move up and is squeezed between the wing and the other air in the sky. That makes air on the top of the wing move more quickly than air under the wing.	
D) Whenever air moves faster, air pressure is lower. The wings are pushed toward the place with the lowest air pressure, that place is up!	
E) The faster an airplane moves, the faster the air moves over the top of the wing. That means a big difference in air pressure between the top and the bottom of the wing. That big difference in air pressure is what **keeps** the plane up.	

Master #8

Name: _____

Date: _____

Flying Things

Flying Animals			
Gliders	Self-propelled Fliers (with wings)		
	Birds	Other Animals	Insects
(animals needing a propelling force to get them into the air; usually by jumping)			

Aircraft

Gliders	Self-propelled Fliers (with fixed or rotary wings)	
	Jet	Propeller
(aircraft needing an external propelling force to get them into the air)	*(forward thrust generated by hot gases)*	*(forward thrust generated by air movement caused by spinning propellers, which are driven by engines)*

3.4

Flying in Birds.

The birds wings are used for flying - their special shape enables this to occur.
The feathers enlarge the wing surface and the flight muscle makes flight possible.
While the bird flies, the wings flap upward and downward. The downward movement is quicker than the upward movement.
The tail serves as an organ for steering and braking.

Downward stroke

Upward stroke

The lungs of birds are made up of air sacs. They also help to keep birds in flight

An interesting assignment would be to do a study of the structure of the lungs of any bird / birds of your choice, and how the lungs help birds fly.

Notes.

Name: _____ **Master #9**

Date: _____

Fly Like a Bird

Facts about how a bird flies:	Show with diagram and labels:
A bird has a smooth, streamlined shape.	
A bird's wings, and each of its feathers, are shaped much like an aircraft's wing--curved on top and flatter underneath.	
Its flight is powered by large muscles inside its body. Powerful chest muscles flap the wings up and down.	
A bird's collar bone is fused in a "wishbone" shape that forms a rigid frame so its body is not squashed when the powerful wing muscles contract.	

Fly like a Bird Cont'd

Name:_____

Date:_____

Facts about how a bird flies:	Show with diagram and labels:
The tail is used for steering.	
Wings are covered in tightly fitting feathers that trap the air.	
A bird's wing can change shape. As the wings beat down, they push the air backwards. Special feathers at the tip of the wings come together to help push the air back. This makes the bird move forwards.	

Fly Like a Bird Cont'd

Name: _____
Date: _____

Facts about how a bird flies:	Show with diagram and labels:
When the wings are pulled up, the tips of the wing feathers move apart to let air flow through. This reduces air resistance and means the bird uses less energy pushing against the air.	
To take off, a bird has to beat its wings very hard to force air quickly over the upper surfaces and produce lift. Once it has climbed high enough, the rate of beating can be reduced.	
The bones of a bird contain many hollow spaces, making the bird lightweight but strong.	

Name: _____

Date: _____

Specialties of a Bird

Name of bird: _____

Top view of the bird's wing: (diagram with labels)

Front view of the bird's wing: (diagram with labels)

Bird adaptations for flight include:

- _____
- _____
- _____

Name: _____

Master#11

Date: _____

Fly Like an Insect

How insects fly:	Show with diagram and labels:
Generally, insects are small and lightweight.	
Insect wings are much thinner and flatter than bird wings. They are often flat when at rest.	
The wings take on curved shape of an aerofoil once they beat against the air.	
As an insect flaps its wings down, they push against the air. This pushing moves the insect upwards and forwards.	
Some insects have single wings and some have double wings.	

Fly Like an Insect Cont'd

How insects fly:	Show with diagram and labels:
Insect wings are attached to the middle body section called the thorax.	
Some insects with two pairs of wings join the front and back wings together. This makes a bigger surface to push against the air.	
Insects have specialized flight muscles to power their wings.	
Insect flight muscles have to be warm before they will work. Their body temperature varies with the temperature of their immediate environment, so when it is cold outside, their body temperature is too low to fly.	

Name: _____

Date: _____

Master #13

Adaptations

What special adaptations allow different species of birds and insects to fly?

	Birds		Insects	
species				
skeleton				
body temperature				
mass				
body shape (diagram)				
wing structure (diagram)				
wing movement (i.e. speed, direction)				
wing covering				
tail				
other				

Master #14

Name: _____

Date: _____

Why *Can't* They Fly?

Why can't penguins and ostriches fly?

	Penguins	Ostriches
skeleton		
mass		
body shape (diagram)		
wing structure (diagram)		
wing movement (i.e. speed, direction)		
feathers		
tail		
special adaptations for travel and speed		

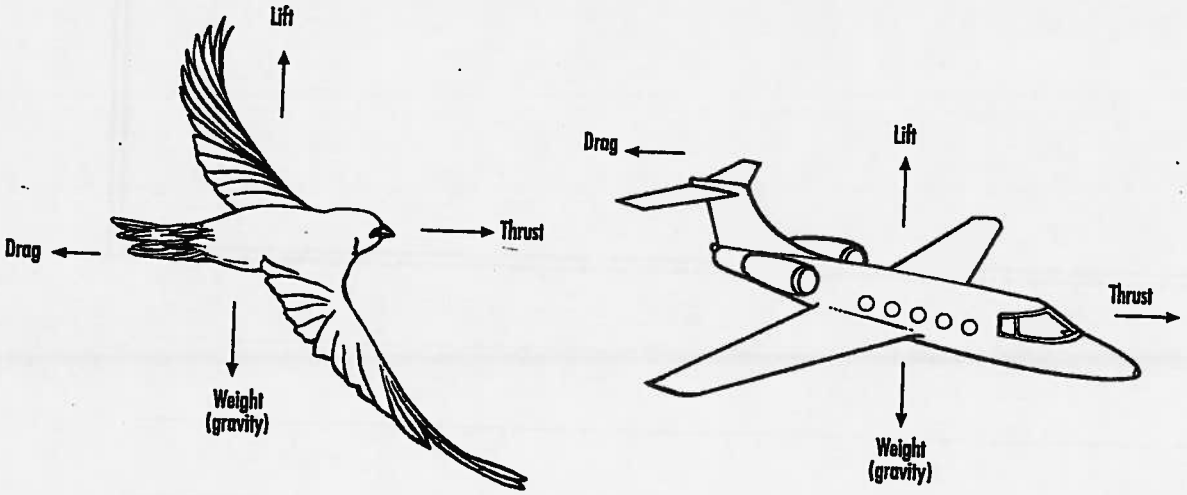
Name: _____

Date: _____

Master #15

Bird Wings and Airplanes

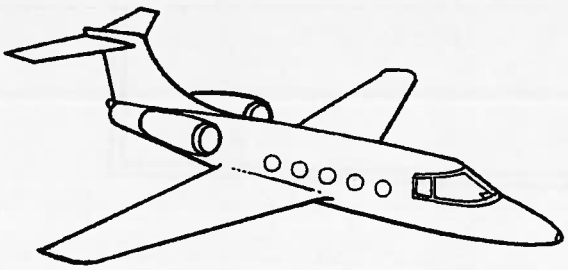
Four forces of flight:



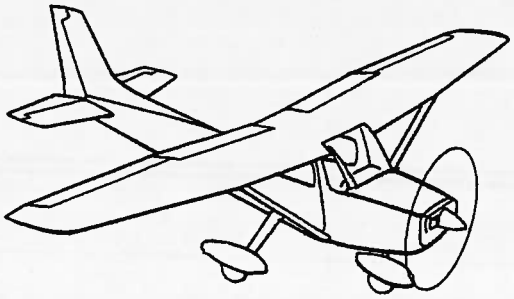
What an aircraft does in the air depends on the balance among the four forces involved in flight. If the lift is greater than the weight, the plane will go up. If the thrust is greater than the drag, the airplane will speed up. If the lift and the weight are equal, and the thrust and drag are equal, the airplane will fly at a steady height and speed.

Aircraft use two basic forms of propulsion- the propeller and the jet. Propellers will be driven by an engine while the jet works on the principle of forward thrust generated by hot gases.

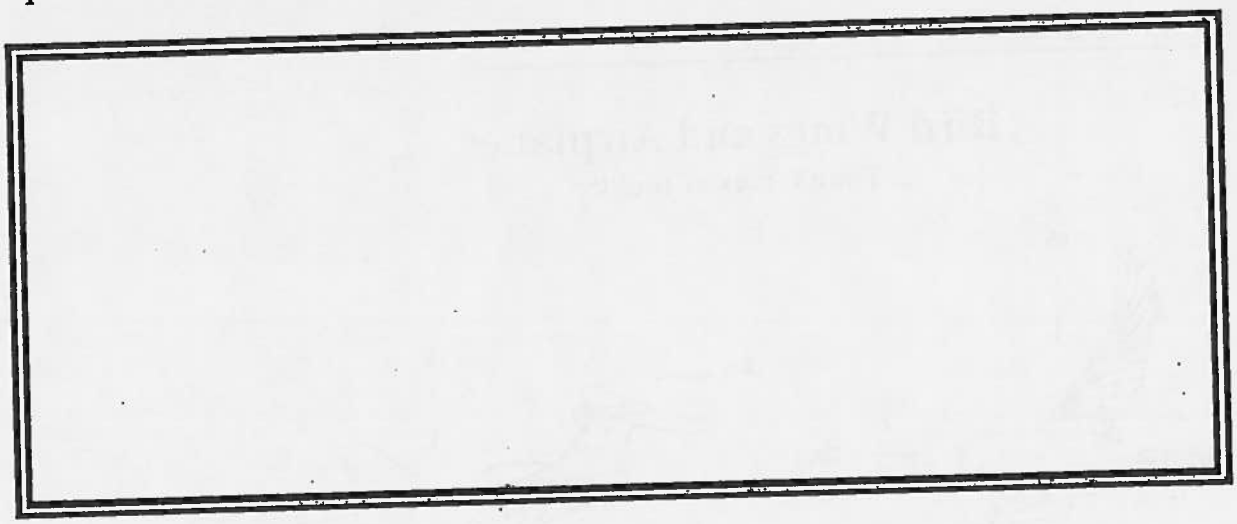
Jet



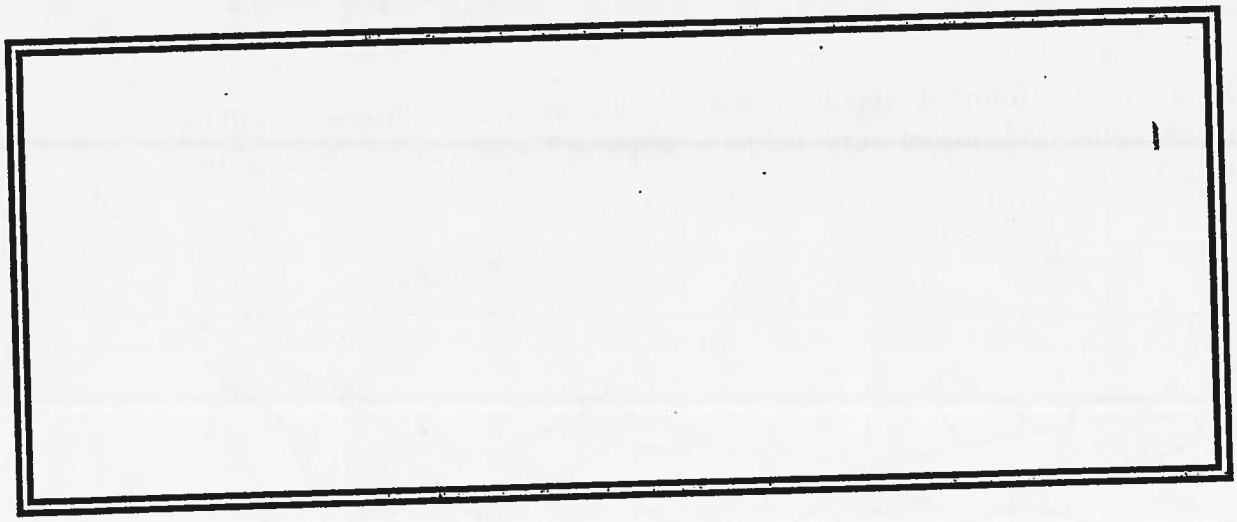
Propeller



Describe how a bird gets *lift*. Draw a picture of a bird's wing and label *low* and *high* air pressure and *lift*.



Describe how a bird gets *thrust*. Draw a picture of a bird's wing that gives *thrust*.



What are the two basic ways that aircraft propel themselves?

_____

_____

Sketch and label each method of propulsion:

The four forces of flight are:

- _____
- _____
- _____
- _____

If the airplane is flying, what would happen if:

the lift becomes greater that the weight?	
The thrust becomes greater than the drag?	
the lift, weight , thrust and drag become equal?	
the thrust becomes less than the drag?	
the lift becomes less than the weight?	

47

Task: Fantastic Flight

Name: _____

Date: _____

Make a poster to show how a _____ flies.

Other students will be learning from this poster so make it:

- accurate
- interesting
- informative

Your poster should have:

1. a clear diagram that illustrates how a _____ flies

2. labels indicating thrust, drag, lift, mass

3. labels pointing out specific flight adaptations (i.e. tail shape, wing shape...)

4. three to five facts written in your own words and in point form about:
   - how the animal flies (i.e. wing movement, speed, distance...)
   - its special adaptations for flight (i.e. streamlined body....)
   - a list of your sources of information including author, title, publisher, and date

5. a descriptive and catchy title so people will know right away what your poster is about.

This project is due on: _____

My goal is to earn _____ on this project.

48

Task: What does a good poster look like?

Name: _____

Date: _____

Excellent	Good	Needs work
Diagram is: • accurate and insightful • detailed • thrust, drag, lift, mass clearly labeled • 3 or more special adaptation features clearly illustrated and labeled	*Diagram is:* • accurate and reasonable • detailed • thrust, drag, lift, mass labeled • 2 or more special adaptation features clearly illustrated and labeled	*Diagram is:* • occasionally accurate • little, if any detail • thrust, drag, lift, mass labeled • adaptation features illustrated
Additional information about flight and aerodynamics: • 5 or more points • accurate • interesting • point form • paraphrased in own words	*Additional information about flight and aerodynamics:* • 3 or more points • accurate • point form • in own words	*Additional information about flight and aerodynamics:* • 2 or less points • not always accurate • needs to paraphrase information into own words
Reference list • Complete and accurate	*Reference list* • Complete	*Reference list* • Incomplete
Title is: • clear • descriptive • catchy and artistic	*Title is:* • clear • descriptive	*Title is:* • needs to be clearer and more descriptive
Over all: • few or no spelling errors • readable print	*Over all:* • few spelling errors • readable print	*Over all:* • several spelling errors • readable print

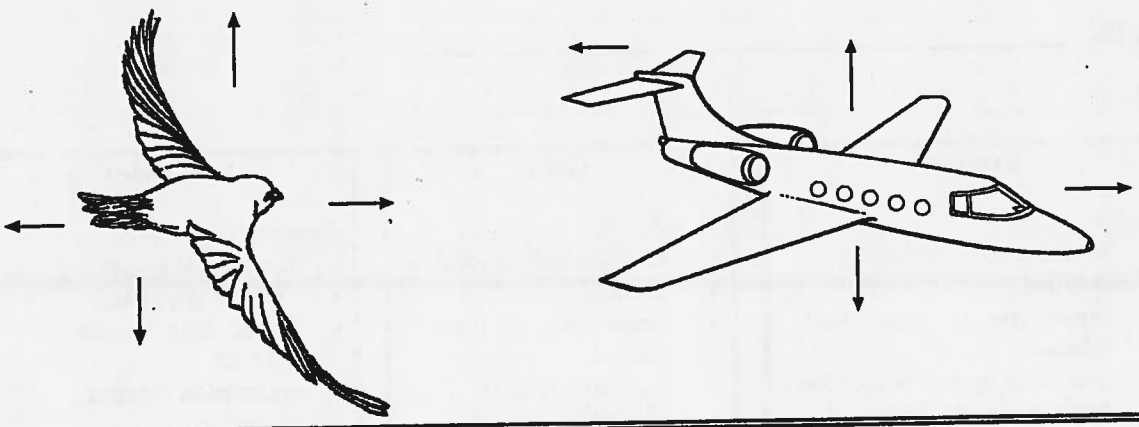
Name: _____

Date: _____

Master # 16

Thrust, Drag and Lift

Forces of Flight



Draw and label the forces of flight for the following:

Bird	**Helicopter**
Hovercrafts	**Paper Airplane**

Thrust, Drag and Lift Cont'd

Imagine an airplane flying through the air. Use what you know about lift, drag, mass, and thrust to tell what will happen to this airplane.

If lift becomes greater than mass, the plane _____.

If thrust becomes greater than drag, the plane _____.

If thrust becomes less than drag, the plane _____.

If lift becomes less than mass, the plane _____.

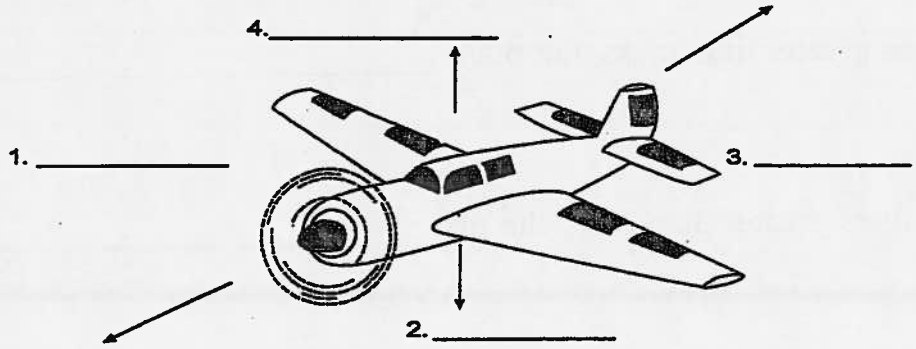
If lift, mass, thrust, and drag become equal, the plane _____

_____.

Task: **Forces of Flight**

Name: _____

Date: _____



1. You are writing your exam to become an airplane pilot. In the above diagram, label the forces which act upon an airplane in flight.

2. You have passed your pilot's exam and are now piloting an airplane flying through the air. Use what you know about the four forces which act upon an object in flight to tell what will happen.

   a. If lift becomes greater than gravity, the plane

   _____

   b. If thrust becomes greater than drag, the plane

   _____

c. If thrust becomes less than drag, the plane

_____

d. If lift becomes less than force of gravity, the plane

_____

e. If lift, gravity, thrust, and drag become equal, the plane

_____

3. You are now an experienced pilot and builder of a new model of aircraft. It needs improvement. What would you do to the design or flight of your aircraft in each case?

a. To increase thrust I would _____

_____

_____

b. To increase lift I would _____

_____

_____

c. To decrease drag, I would _____

_____

_____

d. To increase drag, I would _____

_____

_____

4. You have just ordered a new plane for your company. You want to carry more passengers than it was originally designed for. How could you modify the plane design to carry the additional passengers?

Task: Fantastic Flight of a Bird

Name: _____

Date: _____

1. Draw a bird and label its parts.	2. Explain how a bird is able to fly.
3. Compare and contrast the flight of an airplane and that of a bird.	4. Provide examples of birds that are unable to fly. Explain why they can't fly.

Task: **Adaptations**

Name: _____

Date: _____

Birds and insects have adapted for flight in various ways.
Explain how each characteristic on the table has been adapted to make flight of birds and insects possible.

	Birds	**Insects**
Wing Shape and Structure		
Skeleton		
Body Temperature		
Mass		

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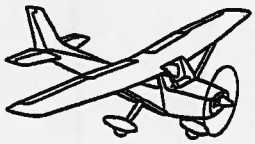
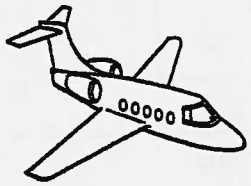
	Birds	Insects
Body Shape and Structure		
Wing Movement		
Wing Covering		
Tail		
Other _____ _____ _____ _____ _____		

Task: How Do They Do That?

Name: _____

Date: _____





Aircraft and flying animals are able to propel themselves through the air by manipulating and controlling the four forces of *thrust*, *drag*, *lift* and *gravity*. In the table below, briefly explain how aircraft and birds manipulate or control each force. In the Compare column, indicate whether they are mostly the same or different.

	Aircraft	Birds	Compare
Lift			
Thrust			
Drag			
Gravity			

58

Task: **What A Drag!**

Name: _____

Date: _____

1. Design a demonstration which will illustrate that drag (resistance, friction) will affect the movement of an object through the air.

   Hypothesis: _____

   _____

   _____

   _____

   Materials: _____

   _____

   Procedure: _____

   _____

   _____

   _____

   _____

   _____

   _____

   _____

Now, carry out your own demonstration.

Observations:

2. In what way did drag affect movement of an object through the air in your demonstration?

60

3. Describe two examples that demonstrate the force of drag is necessary for the correct operation of a flying object.

   a. _____

   b. _____

4. You have the following items to demonstrate aerodynamics:
   - ping pong ball
   - paper clip
   - feather
   - inflated balloon
   - cotton ball

   You drop each of these items from the same height. Complete the following chart.

	Time in the Air	Explanation
ping pong ball		
paper clip		
feather		
inflated balloon		
cotton ball		

61

Name: _____ **Master#17**

Date: _____

Streamline Your Performance

Drag is an obstacle in many sports, and the faster the sport, the greater the drag.

Drag is the resistance you feel when you skate, ski, bicycle, or run faster. You encounter drag as you move through the air or water. Drag opposes motion.

Find out how these athletes make modifications to "streamline" their performance.

Modifications to *reduce* drag

	clothing	equipment	body position	other
skier				
cyclist				
swimmer				

Modifications to *increase* drag

wind surfer	
sky diver	

62

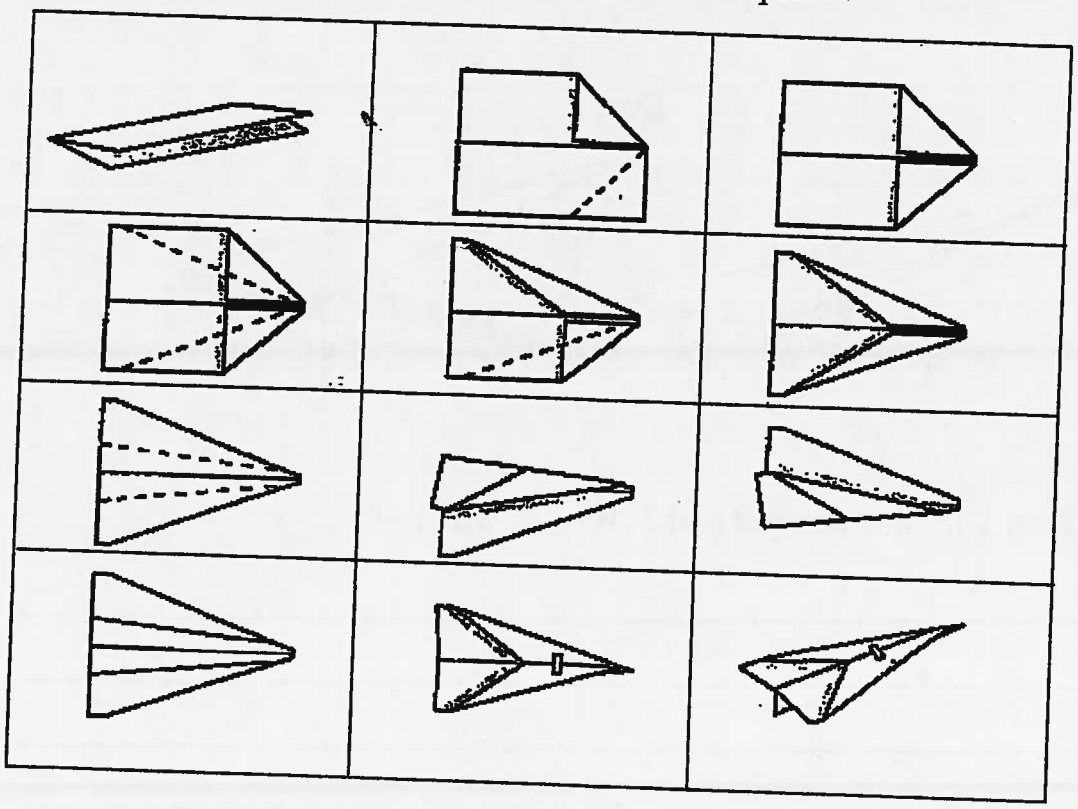
Name: _____

Date: _____

Master#18

Dart and Drag

Instructions for making a dart airplane:



Distancetraveledfirstthrow: _____

Distancetraveledsecondthrow: _____

Howcanyouexplainthisdifferenceindistancetraveled?

_____

_____

_____

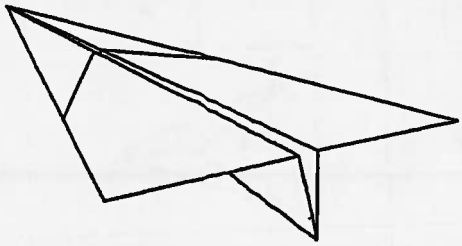
_____

Task: **Dart and Drag**

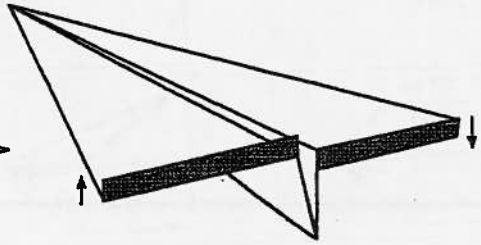
Name: _____

Date: _____

Dart 1



Dart 2



1. a. Will Dart 1 fly in a straight path? Why or why not?

_____

_____

_____

_____

_____

b. How could you get Dart 1 to turn to the left on its next flight?

_____

_____

_____

_____

2. a. Predict how bending one elevator up and one elevator down as in Dart 2 on the previous page will affect the flight of your dart.

b. Fly your dart several times to test its flight.

c. Describe how the dart flew. Did it fly this way each time you threw it?

d. Relating your answer to the concept of drag, what do you think would cause your dart to fly in this manner?

3. Predict what would happen if you folded both elevators up. What would happen if you folded both elevators down? Do an experiment by folding both elevators up, and then both elevators down. After several trials of each, what did you observe about the flight of your paper airplane?

   a. Elevators up _____

   _____

   Explain why you think this happens.

   _____

   _____

   _____

   b. Elevators down _____

   _____

   Explain why you think this happens.

   _____

   _____

   _____

4. Based on the results of your experiments, what do you think a pilot would do with the airplane's elevators to:

   a. Land the airplane? _____

   _____

   b. Climb over a mountain? _____

   _____

Name: _____

Date: _____

Master # 20

Lights Out

How long will the candle burn?

Size of jar	Prediction	Observation
small		
bigger		
biggest		

Inference (*Why* did the candles burn at different rates?)

_____

_____

_____

_____

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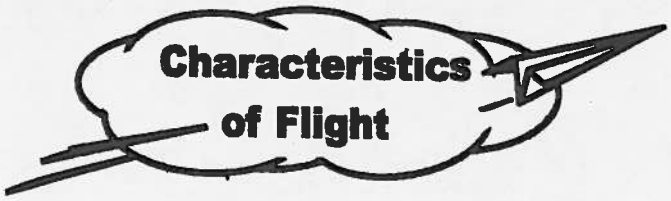
Wordsearch

H	M	V	S	R	F	L	I	G	H	T	E
E	I	I	Q	N	E	T	S	U	R	H	T
L	X	X	W	L	O	N	D	R	A	G	F
I	R	E	D	D	U	R	I	E	B	S	U
C	O	N	C	O	R	D	E	L	T	A	S
O	T	B	O	E	I	N	G	L	R	V	E
P	A	R	A	C	H	U	T	E	I	I	L
T	V	G	O	L	L	W	F	P	P	A	A
E	E	G	V	P	L	N	I	O	L	T	G
R	L	O	Y	H	R	O	L	R	A	I	E
R	E	D	I	L	G	I	O	P	N	O	V
W	A	E	O	T	P	L	A	N	E	N	A

ailerons
airliner
airport
aviation
balloon
boeing
concorde
drag
elevator
flight
fuselage
glider
helicopter
lift
parachute
plane
propeller
rudder
thrust
triplane



Wordsearch Planes

M	X	L	B	S	S	H	V	I	L	S	A	T
E	C	O	I	E	P	E	G	A	A	T	I	M
S	O	C	P	A	I	R	L	I	N	E	R	W
S	N	K	L	P	T	C	I	R	C	A	S	R
E	C	H	A	L	F	U	D	P	A	L	H	G
R	O	E	N	A	I	L	E	L	S	T	I	I
S	R	E	E	N	R	E	R	A	T	H	P	L
C	D	D	F	E	E	S	C	N	E	H	Y	P
H	E	L	I	C	O	P	T	E	R	J	H	I
M	H	A	R	R	I	E	R	B	L	I	M	P
I	J	U	N	K	E	R	S	W	O	F	Z	E
T	R	I	P	L	A	N	E	J	P	Q	Q	R
T	O	R	N	A	D	O	Y	R	L	A	Q	Y

airliner
airplane
airship
biplane
blimp
concorde
glider
harrier
helicopter
hercules
junkers
lancaster
lockheed
messerschmitt
piper
seaplane
spitfire
stealth
tornado
triplane