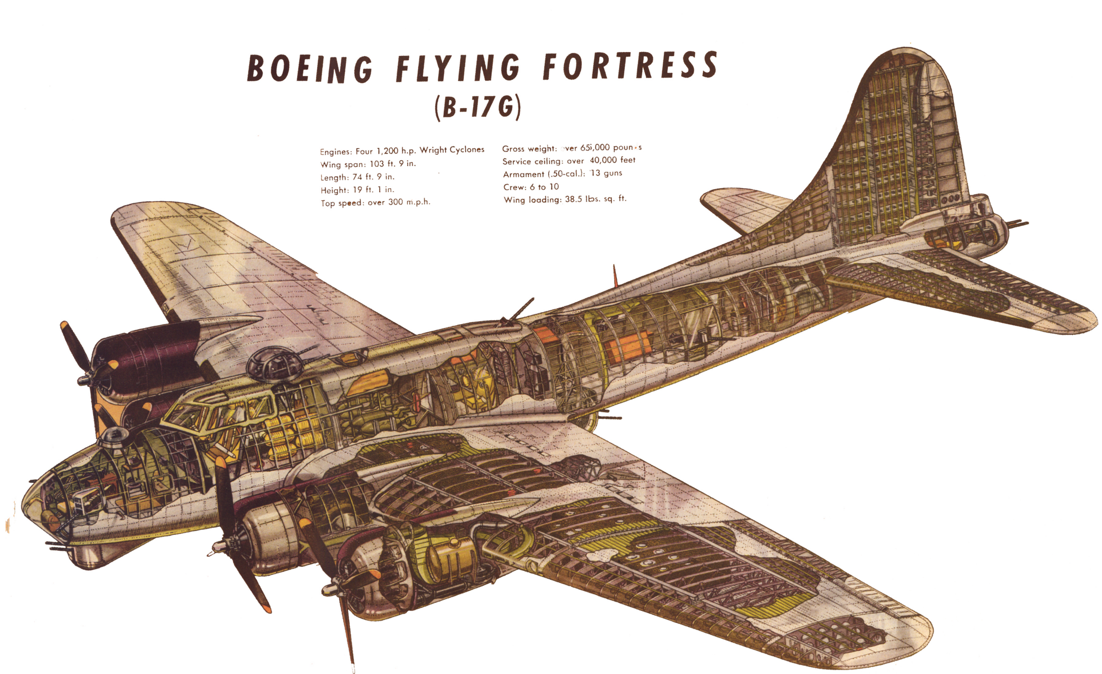
Unit 1: Flying Airplanes



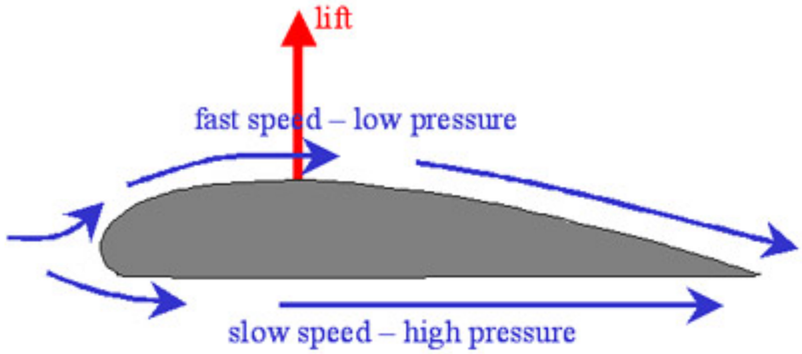
(El-HS) Pretest: Given before going over information on paper.

1) Why does an airplane fly (lift)? A) Bernoulli's Principle B) Newton's 1st Law C) Newton's 2nd Law D) Newton's 3rd Law E) A and D
2) For every action there is an equal and opposite reaction. (When air hits an airplane the airplane moves in the opposite direction of air that bounces off, or is pushed behind) This is A) Bernoulli's Principle B) Newton's 1st Law C) Newton's 2nd Law D) Newton's 3rd Law
3) If an object (airplane) is in motion (straight line), it continues to be in motion (straight line) at the same speed, unless an outside force act on it (usually propeller, jet, air friction and gravity). This is A) Bernoulli's Principle B) Newton's 1st Law C) Newton's 2nd Law D) Newton's 3rd law
4) F=ma (for accelerating airplanes), or mg (for falling airplanes). This is A) Bernoulli's Principle B) Newton's 1st Law C) Newton's 2nd Law D) Newton's 3rd Law

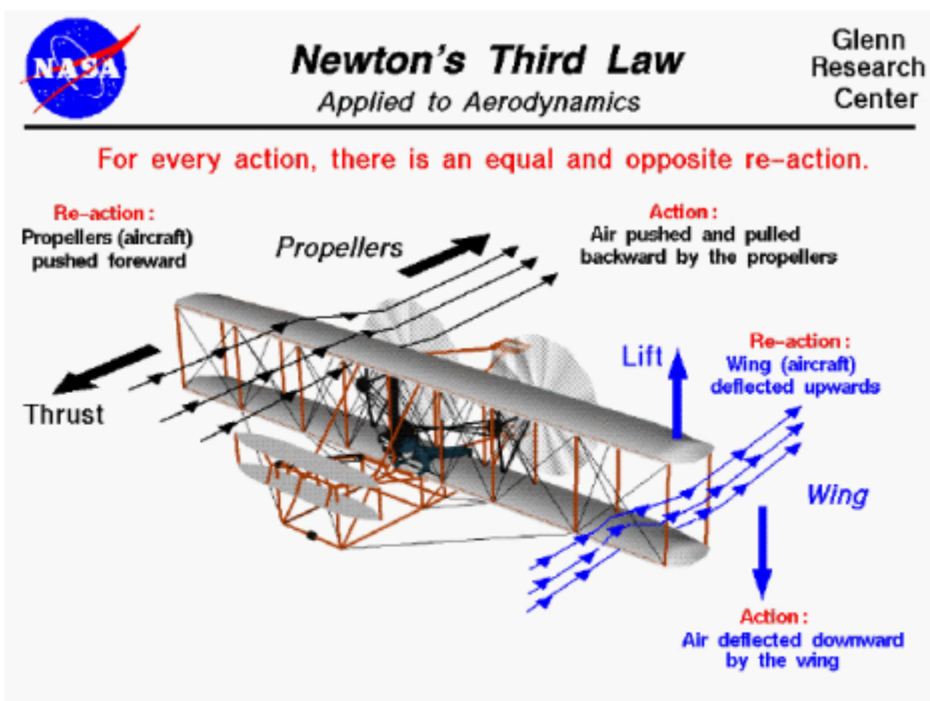
5) When fluid molecules (air) hit the wing creating a faster speed on top of an airplane wing, this creates a low pressure creating lift is explained by A)Bernoulli's Principle B) Newton's 1st Law C) Newton's 2nd Law D) Newton's 3rd Law
6) The force that slows an airplane is called A) lift B) drag C) thrust D) Bernoulli's E) Newton's
7) What is the pathway of a package that is dropped from an airplane in the air? A) straight down B) circular C) diagonal D) parabola E) ellipse

Why does an airplane fly: An airplane moves forward due to a force (push or a pull) sometimes called *Thrust*. An airplane flies, or rises by the *Lift*, or upward force, on the wings of the airplane, it can be caused by the force that occurs when fluid molecules (air) hit the wing and split over and under the wing and return, the longer path on top creates a faster speed and a lower density, so that the fluid molecules can return next to the original neighbors, this also creates a low pressure, less force/area

(Causing lift on an airplane). This is called the *Bernoulli Principle*.

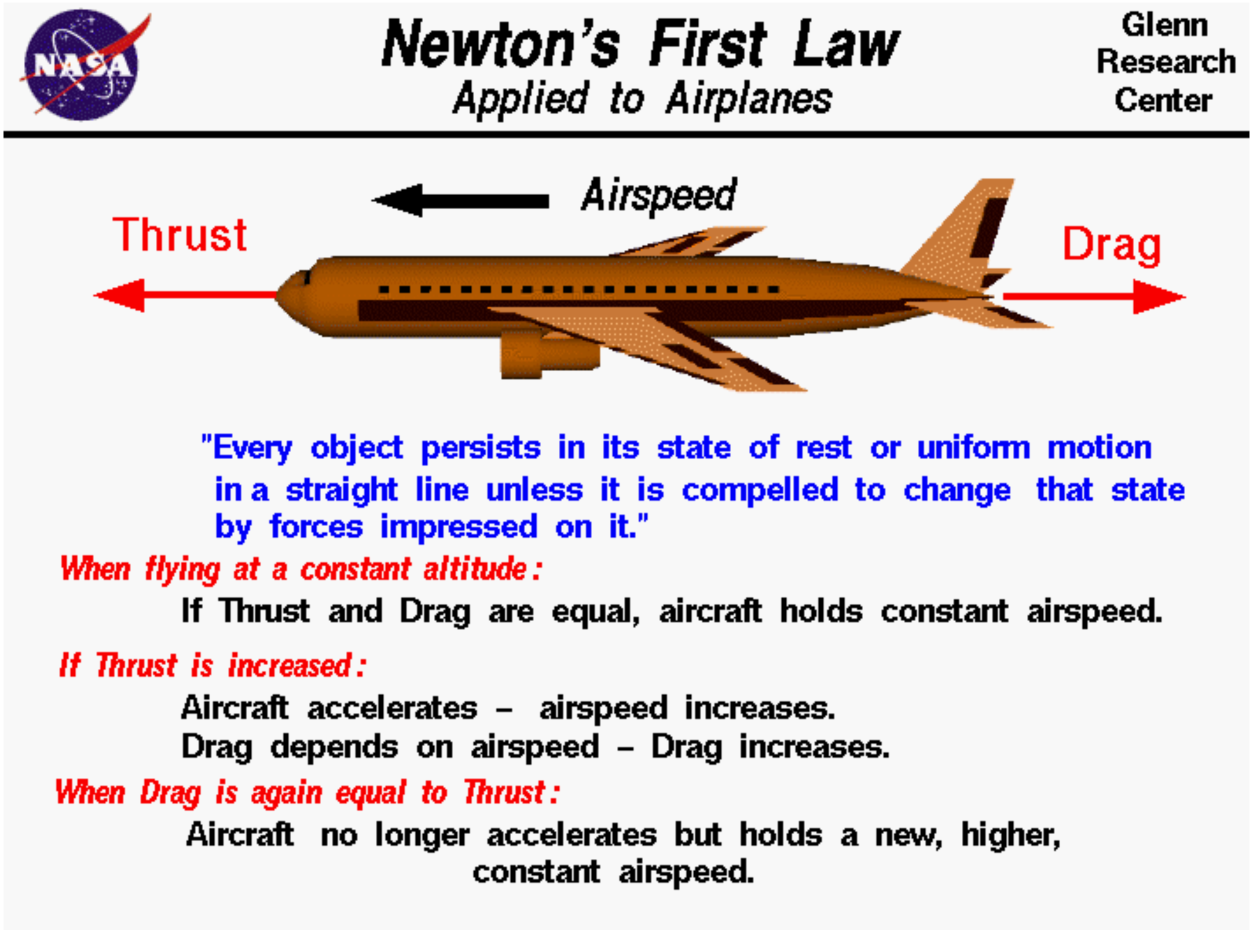


Lift can also occur when the bottom side of the wing hits air at an angle upwards and air pushes the plane up. This is due to **Newton's third Law of Motion.**

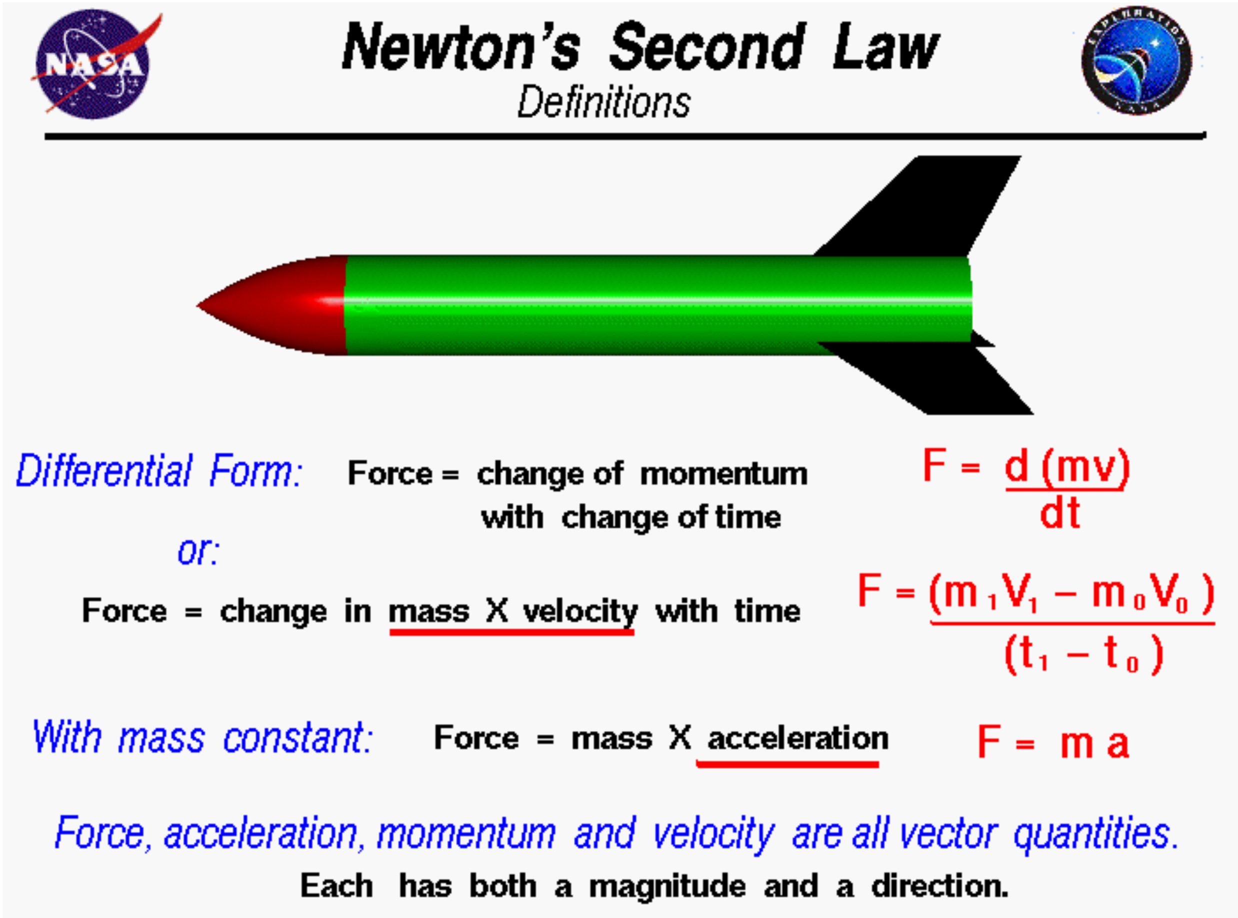


An airplane also glides by the air friction it has with the bottom of the airplane. An airplane continues to move due to ***Newton's first law of motion.*** The airplane is in motion it will continue to be in motion (inertia, and has momentum (mv)) until an outside force opposes the motion (usually friction). Airplanes slows down due to the air friction hitting the front of the airplane this is called

Drag



The airplane falls due to gravity pulling on the airplane toward the center of the earth (Weight**).** This is due to Newton's second law of motion F= ma = mg = weight ($g=9.8\ m/s^2$).



Bernoulli Principle demonstrations

Take a long strip a paper and blow on top of it. What happens? Blow air between two bottles, or balloons that are hung on string which is connected to the ceiling, or a meter stick. What direction do the bottles, or balloons go? With glasses on, turn on the shop vacuum in reverse and place a ball in the air stream. Can you keep the ball in the air? Try to change the angle of the air hose to make the ball move to the right, or left a little. Why does the ball defy

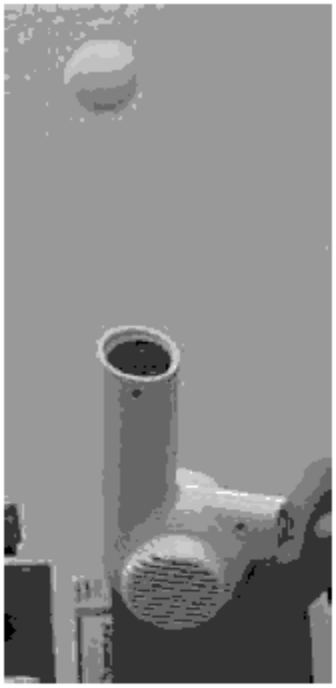
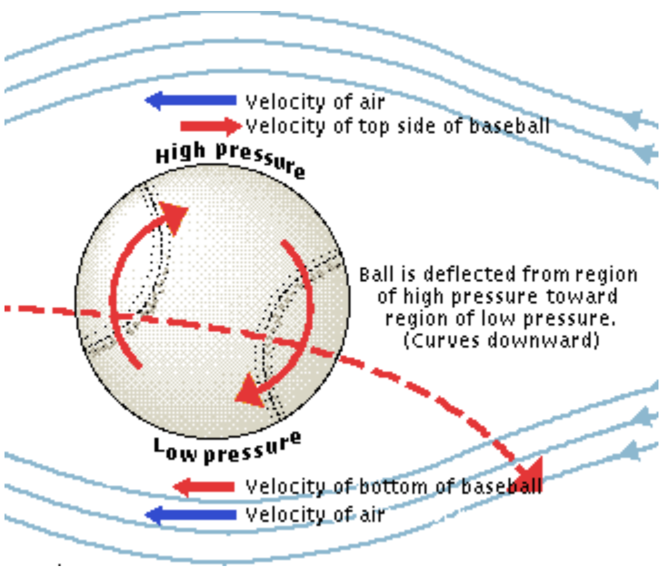


Figure 43-2 *Ping pong ball levitated by Bernoulli's principle.*

gravity? Take a ping pong ball and hit it with sidespin to the left (follow through to the left, and forward). Which way does the ping pong ball go**?**



Definitions:

Measurement: Comparing a known to an unknown amount. (Like a ruler, or a scale)

Base quantities: Everything else can be measured by using combinations of quantities like length(l), or distance(d), mass(m), and time(t).

Units: A basic measurement like a meter that we compare objects. Length: meter(m), mass: kilogram(kg): time: second(s).

Displacement: (d) The distance something travels, a change in position-The vector (resultant) distance (Something moves) (m)

Motion: The displacement of an object (m)

Speed: Distance divided by time (m/s) = $\Delta d/\Delta t$ (How fast something moves) Δ means change (final – starting value)

Project 1: Make a paper airplane. Given paper, fly from the ground, and, or fly from a certain height.

PROJECT 2: *MAKE A MANILA FOLDER AIRPLANE. GIVEN A TEMPLATE.*

Project 3: Make a rubber band powered airplane. Given, foam, or balsa wood.

Topics covered: Measurement of time and distance, calculation of the average speed.

How to make a Paper Airplane

One way to make a paper airplane:

1. Fold a piece of paper in half to make a crease.
2. Unfold the paper and take the upper left corner and fold it into the middle crease.
3. Do the same to the right corner (The corners should meet in the middle crease).
4. Do the same to the upper right and left corner of the pentagon. (Both sides should meet in the middle crease).
5. Pull the lower right and left corners up keeping the same middle fold.
6. Point tip of plane to the left. Create a wing by grabbing both sides of the middle fold with your left thumb and forefinger and make the wing by folding down about an inch above the center fold to the left and one away from you to the right. Please, only throw your paper airplane with the permission of your teacher or parent. Hold the middle with the wings above your fingers and throw slightly upwards.
7. Possible improvements:
   a) Fold the nose (top one inch of the airplane) into the middle fold.
   b) Put a paper clip on the nose.
   c) Make a small downward, or upward fold at the bottom one inch of the wing.

d) You can experiment with other designs to improve your airplane.

Directions for manila folder airplane:

1. Open a manila folder and flatten it into one sheet.
2. Using the template as a guide, measure one and half inches from the left and the same to the right of the middle fold and draw lines parallel from the middle fold.
3. Measure ¾ of an inch from the left and the same to the right of the middle fold and draw lines parallel from the middle fold.
4. Cut the manila folder at the one and half inch mark to the left and right of the middle fold.
5. Measure 2.5 inches from the top and 3/8 of an inch from the middle, draw a line 2.5 inches long (5 inches from the top).
6. Do the same as 5 except 1 and 1/8 from the other side of the middle.
7. Cut a slit where the line is drawn in step 5 and 6. (You can use a box cutter or poke a hole in the middle of the line with scissors, a pin or the end of a paper clip and use scissors to cut the slit) This is where the wings will go through. The teacher may want to do this.
8. Make a fuselage by folding along lines that were drawn in step 3 and the middle fold. This should look like a square tube.
9. Tape the edges together to hold the fuselage together. Make a wing by cutting a 2 inch by 11.5 inch (length of the folder) and a second 2 ¼ inch by 11.5 inch piece of manila folder.
10. Draw a line 1 ½ inch from 2 ¼ wing, make a fold along the line and tape the two wings together. The top wing should have a small fold on it.
11. Slide the wing in the fuselage.

12. Using the template, Cut out the elevator wing and the tail making a slit on the line in the back of the elevator ¾ of an inch long.
13. Make a 1 ½ inch cut in the top and sides of the back of the fuselage. Make another cut ¾ inch on the bottom of the back of the fuselage. Slide the elevator and the tail into the back of the fuselage.
14. Make folds in the nose of the fuselage and pinch the nose with a paper clip. Take a practice throw at the practice line. Add paper clips until the airplanes glides and flies as you want it to.

Directions for a bottle rubber-band airplane : You may use the directions that are given to you as a guide. Cut out using scissors, or box cutters. Fold, tape, or add paper clips where needed.

1. Obtain a plastic water bottle.
2. Poke, or drill a hole in the center of the bottom of the bottle (large enough to put a rubber-band through it), and the center of the screw cap (large enough to put a paper-clip, through it).
3. Make a propeller by soaking a popcycle-stick, or a tong depressor in water for a minute. Grab both ends of the wood and twist and hold for a minute until the wood remains twisted. (You can buy plastic propellers instead)
4. Drill, or poke a hole in the center of the propeller large enough for a paper-clip.
5. Unfold half a paper-clip and place it through the top of the screw-top, a washer, and the propeller. Bend the paper-clip and hot glue it on the propeller (or, Drill a second hole about an 1/8 of an inch away from the first hole. Bend the paper-clip so it can go back into the second hole and through the hole in the bottle.)

6. Hook a wide rubber-band on the folded part of the paper-clip.
7. Using a thin wooden dowel, or metal coat hanger wire, gently push and stretch the rubber band through the bottom of the bottle, and grab the rubber-band. Place the rubber-band in the middle of another paper-clip to prevent the rubber-band from going back into the bottle. (you can also make a hook from a coat hanger wire and pull the rubber band from the bottom to the top paper-clip)
8. Make a small hole in the top ¼ of the plastic bottle through both sides, using scissors cut a slit for the wing (about 2.5 inches).
9. Make a wing out of either manila folder, or a sheet of foam display board by cutting a 2 inch by 11.5 inch (length of the folder) and a second 2 ¼ inch by 11.5 inch piece of manila folder, or 2 inch by 12 in piece of foam board (skip step 10).
10. Draw a line 1 ½ inch from 2 ¼ wing, make a fold along the line and tape the two wings together. The top wing should have a small fold, or a curve on it.
11. Slide the wing in the fuselage.
12. Using the template, Cut out the elevator wing and the tail
13. Make a slit in the bottle for the tail (perpendicular to the wing) and the elevator (parallel to the wing). And attach the tail and elevator (tape may be needed).
14. Spin the propeller between 80-200 times, and release the propeller.
15. When you go to the practice line, wind the propeller with one hand and throw the airplane with the other hand.

Flying the airplane: Go to the practice starting line with your airplane. Recording your data in your notebook (distance traveled from the starting line, time in the air). Throw, or use a launcher and time how long it stays in the air, and measure how far it goes, and calculate the average speed, distance/time (d/t).

Make adjustments. When you are ready, go to the official starting line and attempt three tries and record the results. Calculate the average speed (d/t). The winner for the longest time in the air, the longest distance traveled, and the fastest average speed, will be based on your best results. (The winner could get additional recognition, extra credit, medal, or a prize). Try throwing the airplane with the tail removed. Write down what happens.

Topics covered:

Science**:** Measurement, displacement, motion, speed, velocity, acceleration, gravity, mass, force, weight, pressure, friction (drag), work, kinetic and potential energy, power, projectile motion, Bernoulli's Effect, streamlining

Math: Addition, subtraction, multiplication, division, substitution, square, square root, solving problems involving rate, and velocity.

Definitions:

Significant figures: How many numbers measured are accurate. Example 25.3 (3 significant figures) 25 (2 significant figures)

Velocity: (v) Speed with a direction (Like up or down)(meters/second)(m/s)

Acceleration: (a) Change in velocity/ change in time = $a = \Delta v/\Delta t$ (Something goes faster or slower)(m/s^2)

Gravity: (g) The force that acts on object above a large object (like the earth) 9.808 m/s^2

Mass: (m) The amount of matter (atoms) in an object (kg)

Force: (F) A push or a pull on an object (Like an airplane) (N)=ma=mg =-kx (Hooke's Law) k= spring constant x=compression distance.

Weight: Force of gravity on an object equals F_g= mg (It can change due to changes in gravity) (N)

Friction (drag): A force that opposes motion (N=kg m/s^2) (It slows down objects and heats it.)

Newton's 1st Law of motion: If an object (airplane) is in motion (straight line), it continues to be in motion (straight line) at the same speed, unless an outside force act on it. (usually propeller, jet, air friction and gravity)

Newton's 2nd Law of motion: F=ma (for accelerating airplanes), or mg (for falling airplanes) F=force, m=mass, a=acceleration, g= acceleration of gravity (9.8 m/s^2)

Newton's 3rd Law of motion: For every action there is an equal and opposite reaction. (When air hits an airplane the airplane moves in the opposite direction of air that bounces off, or is pushed behind)

Bernoull's Principle: When fluid molecules (air) hit the wing creating a faster speed on top of an airplane wing, this creates a low pressure creating lift.

Pressure: Force/area (Weight from your heal to the floor) =F/A (Pa=N/m^2)

Work: (W) Force times distance the object is displaced (Something has to move)=W=Fd (Joule (J)=Nm=kg m^2/s^2)

Energy: (E) The ability to do work. (J=Nm=kg m^2/s^2)

Kinetic energy (K.E.): Energy of motion. (The energy when something is moving) = ½ mv^2 (J=Nm=kg m^2/s^2)

Potential energy (P.E.): Stored energy, or energy of position (The possible energy) = mgh (position) = ½ kx^2 (spring) ($J=Nm=kg\ m^2/s^2$) h=height

Power (P): The rate of work or energy.(How fast you can move something) =Energy/time=E/t= Work/time=W/t =force times distance/time=Fd/t=mass times acceleration times distance/time=mad/t=mgh/t=Fv ($W=Nm/s=kgm^2/s^3$)

Streamlining (laminar flow): Fluid molecules will slide by each other smoothly and reduce friction. (Best with smooth surfaces)

Projectile motion: The parabolic motion (A Curve) that objects take when it falls, or has a force to throw it up (y coordinate) and away (x coordinate)

(**HS**) (They are affected by an x and a y component).
$d=d_0 + v_0t + \frac{1}{2} at^2$

(vertically (y)) Usually $d_0 = 0$ and $v_0=0$ then

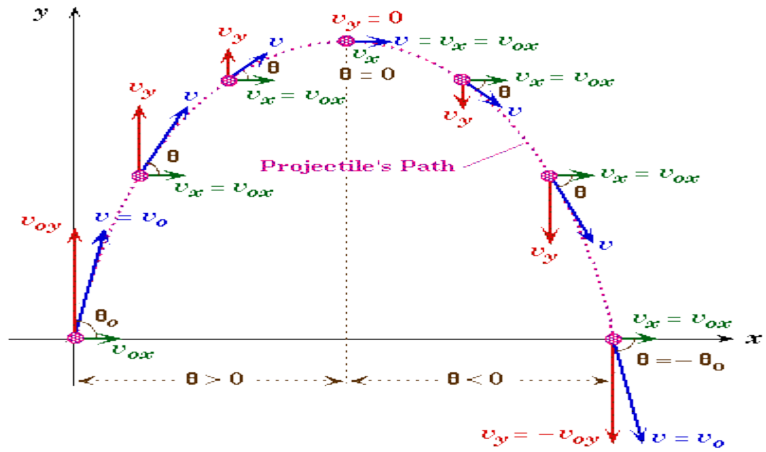
$y= h=\frac{1}{2} gt^2$ multiply both sides by 2 and then
$2h=gt^2$ divide by g and then
$2h/g = t^2$ take the square root of both sides and then

$t=2h/\square$

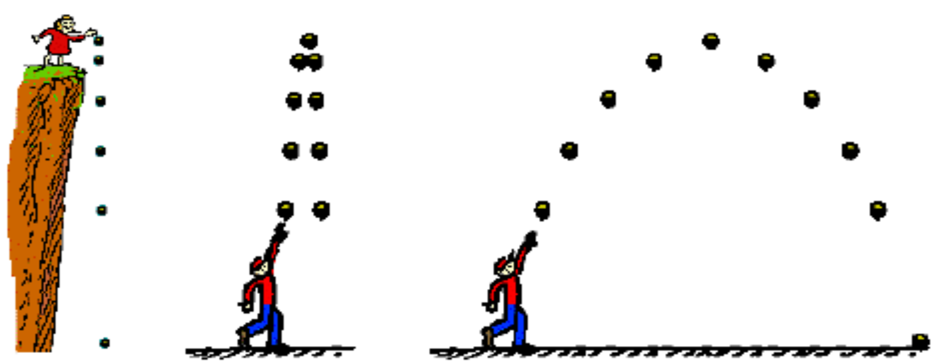
(horizontally(x)) Usually $d_0 = 0$, $a = 0$, and then
$x = d = v_0t$

Projectile motion demonstration

Take a ball and take a video with a smart phone with you throwing it up in the air. Look at the video in slow motion and describe the motion. Repeat, this time, throw the ball towards the wall. This motion is sometimes called projectile motion.



Types of Projectiles



$$s = v_0(\cos\theta)t$$

$$h = v_0(\sin\theta)t - \frac{1}{2}gt^2$$

The shape should look like a parabola.

Calculate: The acceleration (a) of the airplane from rest to before it reaches constant speed (v).

Example: If an airplane starts at rest and reaches 20 m/s in 4 seconds, how much did it accelerate? a= Δv/Δt=(final velocity-starting velocity)/(final time-starting time)= (usually) speed/time when starting at rest (not moving)

a= Δv/Δt = (20 m/s)/(4 s) = 5 m/s^2

Example: An airplane is 4.4 m above the ground. It reaches a constant speed, when the initial distance is 8.1 m. It travels to a final distance of 22.2 m in a time of 5.2s. The target is at the 40 m mark and $g = 9.8\ m/s^2$. Calculate

1. The average speed
2. The time to hit the ground
3. The time to travel horizontally
4. The distance traveled horizontally when you drop a bomb
5. At what distance mark do you drop the bomb

Calculations

1. Average speed = v= Δd/Δt = (22.2 m – 8.1 m)/ 5.2 s = 2.72 m/s = 2.7 m/s (2 significant figures)
2. t=2hg =*(2) 4.4 □/(9.8 □/ □2)* = [.898] = .947 s= t_y = .95 s(2 significant figures)
3. The time to fall is the same as the time to travel horizontally (t_x) = .95 s
4. Distance traveled horizontally (d_x) = if v=d_x/t multiply both sides by t and then
   d_x = vt = (2.7 m/s)(.95 s) = 2.6 m
5. You must drop the bombs 2.6 m before the target. If the target is at the 40 m mark then you must drop the bomb at the (40 m-2.6 m)= 37.4 m mark.

Michigan Benchmarks covered: P2.1, P2.2, P2.3x, P3.1, P3.1x, P3.2, P3.4, P3.5x, P3.6, P4.1, P4.1x, P4.2, P4.3, and P4.3x.

Michigan GLCE covered: (K-4) IP, IA, FM, EN, (5-7) IP, IA, FM, EN, A.PA.06.01, N.MR07.02

Next Generation Science Standards:

Elementary Standards: K-PS2-1, K-PS2-2, K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3, 3-PST2-1, 3-PS2-2, 4PS3-1, 4-PS3-2, 4-PS3-4

Middle School Standards: MS-ETS1-2, MS-ETS1-3, MS-PS2-1, MS-PS2-2, MS-PS2-4, MS-PS3-1, MS-PS3-2, MS-PS3-5

High School Standards: HS-PS2-1, HS-PS2-2, HS-PS-2-4, HS-PS3-3

Educational/Career Exploration: Careers that focus on these topics: Aeronautic engineers, mechanical engineers

(4-12)Contest: Have students fly the airplane that they put together and give prizes for longest flight, longest time in the air, fastest airplane. Measure horizontal distance, vertical distance, total time in flight, and calculate average horizontal speed, vertical speed at the ground, resultant speed, and acceleration (2 or more tries)

Alternate contest: B17 Bombing Competition:

Goal: To drop a bomb, and, or supplies on various targets.

Use two stands with wire between stands, 2 airplanes, RC airplane. Targets could be bridges of different sizes, landing fields, battle ships, Communication towers, Radar instillations, ammunitions, and antiaircraft (not people). Drop supplies to troops, or, civilians.

Calculate how far you must drop an object to hit the target given: You will be given two runs of the airplane. The first run will be used to do calculations. The second run you will drop the bombs, or supplies. The speed has to be at least 10 km/hr.

Record the following data for the first run of the airplane:

1. If you use the speed gun v= constant speed (After it has accelerated)
2. If you do not use the speed gun, measure
   d_0= Initial, starting distance used when constant speed has been reached(m)
   d_f = A final distance used to measure the constant speed (First run)
   t= time (s) during the change in distance of constant speed
3. h=height above ground (m) [If you can't measure directly, use a sexton or a protractor and pointer(pencil) and use trigonometry, $\tan\theta = y/x$ [$h=y=(x)(\tan\theta)$], if $\theta =45$ then h=x

(If measured from eye level, measure the distance from eye to ground and then add this distance to the calculated height)]

You need to calculate 1) velocity 2) time to reach maximum speed 3) acceleration of the airplane. Calculate time for the bomb, or supply to fall and the distance to travel horizontally to hit the target, and the acceleration of the airplane from rest to reaching constant velocity.

Measure speed, with distance tags, timer and with a radar gun. Calculate distance and time of measurements, velocity, and acceleration of airplane. Calculate distance the bomb will travel horizontally and vertically using the projectile motion equation

Calculate the acceleration of the airplane: $a = \Delta v/\Delta t$=final velocity-starting velocity/final time-starting time= (usually) speed/time when starting at rest (not moving)

d= distance the bomb travels (m)

d_0= starting distance (m)

h=height above ground (m), if you can't measure directly, use a sexton or a protractor and pointer(pencil) and use trigonometry, $\tan\theta = y/x$ [$h=y=(x)(\tan\theta)$], if $\theta = 45$ then $h=x$ (If measured from eye level, measure the distance from eye to ground and then add this distance to the calculated height)

v_0= Starting velocity (speed) (m/s)

t= time (s), time to hit the ground

a= acceleration (m/s^2)

g= acceleration of gravity=9.8 m/s^2

$d=d_0 + v_0t + \frac{1}{2} at^2$ = (usually $d_0=0$, $a=0$ horizontally) $x = d = v_0t$,
(Usually $d_0=0$, $v_0=0$ vertically) $y = h = \frac{1}{2} gt^2$ ($t=2hg$)

Example: initial distance= 5.2 m , final distance= 22.2 m time = 6.5 s

Average speed = v= (22.2 m – 5.2 m)/ 6.5 s = 17m/6.5 s = 2.62 m/s = 2.6 m/s (2 significant figures)

If the height = 6.4 m time to fall t=2hg = *(26,4 □)/(9.8 □/ s)* = *1.14 □* = 1.1 s (2 significant figures)

The time to fall is the same as the time to travel horizontally (x) = 1.1 s

Distance horizontally x= v/t =(2.6 m/s)(1.1 s) = 2.86 m =2.9 m (2 significant figures)

You must drop the bombs 2.9 m before the target. If the target is at the 40 m mark then you must drop the bomb at the (40-2.9)= 37.1 m mark.

Drop the bomb, or supply at the right place and measure where they actually hit the ground and calculate the percentage error from the target.

Percentage error = |experimental value – actual value|(100)/actual value

PROBLEMS

Questions to give to students before they come to the Yankee Museum

Elementary: 1a) If you push on model airplane, will it move easier with wheels, or without wheels? Why?

(With wheels, rolling friction is less than sliding friction)

1b) If a model airplane is moving toward you and you push it to the side with a noodle, or with wind, what will happen to the path of the airplane?

(The airplane will curve off to the side)

1c) If a model airplane is moving toward you and it goes up a ramp, what will happen to the speed of the air plane?

(It will slow down)

2) What is causing a rocket to go up in the air during take-off?

(Something (gas) pushing down on the ground (action, rocket goes up is the reaction, Newton's 3^{rd} Law of Motion))

3) Why does a rocket keep moving once a rocket stops burning fuel?

(Inertia, or Newton's 1^{st} law of motion)

4) If you blow up a balloon and you let it go, why does it move?

(Newton's 3^{rd} law of motion the air pushes down and the balloon starts going up)

Middle School and Physical Science

Take Off: Problem 1 A) If the space shuttle and fuel tanks have a mass of 2,000,000 kg, what minimum force must the rockets provide to begin lift off?

B) How much gravitational potential energy increase does the space shuttle have after 2 meters?

Orbit: Problem 2. What is the distance traveled by the space shuttle in one revolution of the earth if the radius of the earth is 6,380,000 m and the shuttle is 340,000 m off the ground.

Problem 3. How long does it take the space shuttle in problem 2 to travel one revolution of the earth if it goes 7,700 m/s.

Problem 4. What is the linear kinetic energy of the space shuttle if it is traveling 7,700 m/s orbiting around the earth and has a mass of 90,000 kg.

Solutions Middle School and Physical Science:

Take Off: Problem1 A) If the space shuttle and fuel tanks have a mass of 2,000,000 kg, what minimum force must the rockets provide to begin lift off?

Solution: F=mg (weight)= (2,000,000 kg)(9.8 m/s^2) = 19,000,000 N

B) How much gravitational potential energy increase does the space shuttle have after 2 meters?

Solution: PE= mgh = (2,000,000 kg)(9.8 m/s^2)(2 m)= 39,200,000 J of energy.

2) What is the distance traveled by the space shuttle in one revolution of the earth if the radius of the earth is 6,380,000 m and the shuttle is 340,000 m.

Solution: d=2πr(r=6,380,000+340,000 = 6,720,000 m) = 2(3.14)(6,720,000 m) = 42,000,000 m

Problem 3. How long does it take the space shuttle to travel one revolution of the earth if it goes 7,700 m/s.

Solution: t = d/v = 42,000,000 m/7,700 m/s =5,455 s = 1.5 hours

Problem 4. What is the linear kinetic energy of the space shuttle if it is traveling 7,700 m/s orbiting around the earth and has a mass of 90,000 kg.

Solution: KE= ½ mv^2 = ½ (90,000 kg)$(7,700\ m/s)^2$ = 2,668,050,000,000 J = 2.7 x 10^{12} J

Take Off: Problem 1

A) If the space shuttle and fuel tanks have a mass of 2,000,000 kg, what minimum force must the rockets provide to begin lift off?

B) How much gravitational potential energy increase does the space shuttle have after 2 meters?

C) If the rocket provides 24,000,000 N of thrust during 2 meters, how fast is the shuttle going after 2 meters?

Problem 2. What is the velocity that the space shuttle must achieve in order to orbit around the earth at $.34 \times 10^6$ m?

m= mass of the space shuttle= 9.00×10^4 kg

m_e = mass of the earth = 5.98×10^{24} kg

r_e = radius of the earth = 6.38×10^6 m

h= height above the earth

G= Universal gravitational constant = 6.67×10^{-11} Nm^2/kg^2

In orbit

Problem 3. What is the distance traveled by the space shuttle in one revolution of the earth if the radius of the earth is 6,380,000 m and the shuttle is 340,000 m.

Problem 4. How long does it take the space shuttle to travel one revolution of the earth if it goes 7,700 m/s.

Problem 5. What is the linear kinetic energy of the space shuttle if it is traveling 7,700 m/s orbiting around the earth and has a mass of 90,000 kg?

Problem 6. What is the value of g at the normal orbiting altitude h= $.34 \times 10^6$ m?

Landing:

Problem 7. If you want the space shuttle to land at 96 m/s, how fast should the shuttle be going if there was no air to slow it down? How much heat do the heat shields have to withstand due to the frictional force used to slow down the shuttle at landing speed of 96 m/s if the space shuttle falls 340,000 m. Use the orbital value of g, the orbital velocity in the previous problems, and a space shuttle mass of 90,000 kg?

SOLUTIONS (1-7):

Take Off: 1 A) If the space shuttle and fuel tanks have a mass of 2,000,000 kg, what minimum force must the rockets provide to begin lift off?

Solutions: F=mg (weight)= (2,000,000 kg)(9.8 m/s^2) = 19,000,000 N

B) How much gravitational potential energy increase does the space shuttle have after 2 meters?

Solution: PE= mgh = (2,000,000 kg)(9.8 m/s^2)(2 m)= 39,200,000 J of energy.

C) If the rocket provides 24,000,000 N of thrust during 2 meters, how fast is the shuttle going after 2 meters?

Solution: Fd=mgh + ½ mv^2 = (24,000,000 N)(2 m)= 39,200,000 J + (½)(2,000,000 kg)v^2 Multiply and subtract 39,200 J from both sides of the equation.

48,000,000J – 39,2000 J = (1,000,000 kg)v^2 Divide both sides by 1,000,000 kg

v^2 = (48,000,000 J – 39,200,000 J)/ (1,000,000 kg) = Subtract

8,800,000 J/1,000,000 kg = 8.8 $m^2/s^2 = v^2$, v= *4.4 ▯2/* = 2.96 m/s = 6.6 mi/hr

Problem 2. What is the velocity that the space shuttle must achieve in order to orbit around the earth at .34 x 10^6 m?

m= mass of the space shuttle= 9.00 x 10^4 kg

m_e = mass of the earth = 5.98 x 10^{24} kg

r_e = radius of the earth = 6.38 x 10^6 m

h= height above the earth

G= Universal gravitational constant = 6.67 x 10^{-11} Nm^2/kg^2

Solution: (Centripetal force) $mv^2/(r_e+h)=Gmm_e/(r_e+h)^2$ (Gravitational force) (the m divides out leaving)

$v^2 = Gm_e/(r_e + h)$, v = □□□*(□□+ℎ)* =6.67 x 10−11 Nmkg5.98 x 1024kg =*5.9* □ *107* =7.7 x 10^3 m/s =7,700 m/s

In orbit:

Problem 3. What is the distance traveled by the space shuttle in one revolution of the earth if the radius of the earth is 6,380,000 m and the shuttle is 340,000 m.

Solution: d= 2πr (r = 6,380,000+340,000 = 6,720,000 m) = 2(3.14)(6,720,000 m) = 42,000,000 m

Problem 4. How long does it take the space shuttle to travel one revolution of the earth if it goes 7,700 m/s.

Solution: t = d/v = 42,000,000 m/7,700 m/s = 5,455 s = 1.5 hours

Problem 5. What is the linear kinetic energy of the space shuttle if it is traveling 7,700 m/s orbiting around the earth and has a mass of 90,000 kg.

Solution: KE= ½ mv^2 = ½ (90,000 kg)$(7,700 \text{ m/s})^2$ = 2,668,050,000,000 J = 2.7 x 10^{12} J

Problem 6. What is the value of g at the normal orbiting altitude h= .34 x 10^6 m.

Solution: $F=Gmm_e/(r_e+h)^2$ =mg =, (m divides out leaving) g = $Gm_e/(r_e+h)^2$ = $(6.67 \times 10^{-11})(5.98 \times 10^{24}$ g)/ $(6.38 \times 10^6$ m+ .34 x 10^6 m)^2=8.83 m/s^2

Landing: Problem 7. If you want the space shuttle to land at 96 m/s, how fast should the shuttle be going if there was no air to slow it down? How much heat do the heat shields have to withstand due to the frictional force used to slow down the shuttle at landing speed of 96 m/s if the space shuttle falls 340,000 m. Use the orbital value of g, the orbital velocity in the previous problems, and a space shuttle mass of 90,000 kg?

Solution: mgh+ ½ mv^2 (In orbit)= mgh + ½ mv^2 (Landing) (Divide everything by m)

gh + ½ v^2 (In orbit) = gh + ½ v^2 (Landing)

(8.8 m/s^2)(340,000 m) + ½ (7,700 m/s)^2 = (9.8 m/s^2)(0) +(½ v^2)

Square, then multiply

½ v^2 = 2,992,000+29,645,000)= multiply both sides of the equation by 2

v^2 = 2(32,637,000)= 65274000, v=*65274000* =8079=8100 m/s (2 Significant Figures)

Heat loss =ΔE= ½ mv^2 (without friction)- ½ mv^2 (with friction) = ½ m[v(without friction)-v(with friction)] =

½ (90,000 kg)(8100-96 m/s)^2 = ½ (90,000)(8004)^2 =2,882,880,720,000 J=3 x 10^9 J=3 GJ of heat.

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