USING SIMULATION TO TEACH YOUR STEM CLASS

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BRUCE WEBBER, INSTRUCTOR, CFI, CFII, CFIMEI, CAPTAIN JET BLUE AIRLINES
USE OF FLIGHT SIMULATORS IN THE CLASSROOM

Karnes City ISD Education Foundation provided the funds to purchase three Redbird Jay Simulators.
If you desire to have a career in aviation and flying, join the KCHS AVIATION CLUB. You will learn flying through ground school education, simulator flight training, and have the opportunity to learn about enrollment in Liberty University’s on-line B.S. Science in Aviation Management Program. The culmination of which you can begin flight lessons at Texas Aviation Academy with locations at airports in Kenedy and New Braunfels, Texas. RECEIVE A B.S. DEGREE WITHOUT HAVING TO LEAVE OUR COMMUNITY AND START WORK ON IT TODAY!
It started with an idea of physics in aviation and like most programs, money is required. We presented the idea of teaching physics with simulators and our Foundation provided a grant.
The early beginnings of Physics of Flight Simulation.
A great supporting flight book and a timeless edition for learning the physics of flying is the book *Stick and Rudder*, Wolfgang Langewiesche.

Written well before the proliferation of cockpit electronics, navigational aids, and air traffic control radio, the book focuses primarily on fundamental skills specific to flying the aircraft in its stripped down basic form.
• Bernoulli’s Theorem: how the air moves around the top of the wing, does it speed up on top, slow down on bottom, increase or decrease pressure on top or bottom? What about the molecules of air that leave the first surface and meet at the back of the wing?

• THAT WILL CONFUSE AN AVIATOR PHYSICS STUDENT
WHAT IS ACTUALLY HAPPENING TO AIR ON THE WING
THE FIRST THING ANY AVIATOR STUDENT SHOULD KNOW

• AIR UP FROM THE BOTTOM SURFACE
• AIR DOWN WITH ITS TOP SURFACE
• THIS UP/DOWN FORCE OF THE AIR FROM THE WING,
  PER THE LAWS OF NEWTON,
  MUST BE AN EQUAL AND OPPOSITE FORCE
• AIR IS 14 LBS PER SQUARE INCH EQUALLY
• THE WING GETS THE SAME FORCE

• WING IS BASICALLY AN INCLINED PLANE, HAVING CURVATURE
  CONFORMING TO THE BERNOULLI THEOREM, BUT THE INCLINED PLANE
  HAS MORE TO DO WITH NEWTON’S LAWS THAN ANYTHING ELSE

RECEIVE A FORCE GIVE A FORCE
Why we call this A “plane” or an airplane

It is basically a designed inclined plane

AS THE NAME IMPLIES
“ANGLE OF ATTACK” PHYSICS/SIM..... DEMONSTRATION # 1

HOW CAN BERNOULLI VS. NEWTON BE DEMONSTRATED WITH SIMULATOR?

STUDENTS SHOULD HAVE A BASIC KNOWLEDGE OF USING A FLIGHT SIMULATOR
• Students are to fly straight and level, Cessna 172 at a specific holding altitude
• Trim the aircraft for a few minutes to get stable flight cruising at 2100 rpm
• Reduce power to 1400 rpm
• Ask student to maintain altitude with enough back pressure to keep the airplane level
• Fly level with elevated nose up slightly and level flight at 1400 rpm.
• HAVE A DISCUSSION WITH STUDENT BEFORE THEY DO THIS...........

STUDENTS MAY SAY, “WE WILL STALL”, SOME MAY SAY “CAN’T DO IT BECAUSE YOU TOLD US WE CAN’T”, INTRODUCE SLOW FLIGHT
MAKE SURE YOU GO OVER WITH THE STUDENTS THAT ONE DOES NOT LIKE TO SLOW FLY FOR LONG PERIODS OF TIME. ACTUAL FLIGHT SETTING MAY RESULT IN OVERHEATING OF THE ENGINE.
Student simulation is important, slow flight training simulation is important, and real time flying is important.

Angle of Attack or Slow Flight training is basically the concept of a good Landing AND YOU CAN TEACH THIS BEFORE YOU TEACH LANDINGS.

Landing technique- better to control the airplane in slow flight upon landing than leveling off or “holding off” MAKES LANDING EASIER WHEN THEY UNDERSTAND THE CONCEPT.

SIMULATION TRAINING FOR SLOW FLIGHT OR ANGLE OF ATTACK WILL MAKE YOUR STUDENT PILOTS SAFER AND MORE PROFICIENT “LANDERS”
Nose up Angle of Attack can actually be the airplane moving in most any direction-- it actually does not have to be a nose up to stall the aircraft.
PHYSICS/SIM........ DEMONSTRATION #2

- FROM SLOW FLIGHT, OPEN THE THROTTLE TO 2100 RPM
- HOLD THE NOSE DOWN SLIGHTLY AS THROTTLE INCREASES RPM’S
- STAY AT THE SAME ALTITUDE
- BACK PRESSURE WILL NEED TO BE RELEASED SLIGHTLY
- RETURN TO LEVEL FLYING AGAIN
- AIRCRAFT WILL BE IN A NEGATIVE ANGLE OF ATTACK
  TRANSITIONING TO ANGLE OF ATTACK DOWNWARD

THIS IS A GOOD TIME TO EXPLAIN HOW AN AIRPLANE
FLYS UPSIDE DOWN, WHICH HELPS TO KEEP NEWTON IN
THE PICTURE ........ OPPOSITE FORCES
Airplanes can fly upside-down due to lift created by angle of attack and yet the wing structure is opposing Bernoulli understanding.
FLIGHT PHYSICS IS THE SAME
In slow flight, cruising, or flying at top speeds; the wing meets the air at an “Angle of Attack”, Relative to the Wind......
kicks the air down, and thereby pushes the plane up.

OPPOSING FORCES ACTUALLY WORK ON THE WING
FOR EVERY SPEED THERE IS AN ANGLE OF ATTACK THAT WILL PRODUCE JUST ENOUGH LIFT TO HOLD YOUR AIRPLANE UP

• MORE SPEED=LESS ANGLE OF ATTACK,
• LESS SPEED= MORE ANGLE OF ATTACK
What does weight have to do with the Angle of Attack?
Can I stall at any speed? Yes, definitely Yes (FAA PAR QUESTION)

HAVE STUDENTS REPEAT THE SAME PREVIOUS EXPERIMENT WITH THE AIRCRAFT LOADED WITH AFT WEIGHT.

Students can adjust the weight and CG on the simulator.
Make sure a student takes data and you can record the flight for analysis.
PHYSICS/SIM DEMONSTRATION  # 4
THE PHYSICS OF THIN AIR FLIGHT

• High altitude flight is more efficient on fuel use
• High altitude flight can allow the airplane to fly faster
• Thin air has molecules of air farther apart and fewer of them
• Warmer air has molecules of air farther apart
• The engine will operate with less friction on all parts
Have students select an airfield at a high altitude for this demonstration such as Denver, Colorado; Cheyenne, Wyoming; Dubois, Wyoming; Rock Springs, Wyoming; Butte, Montana (elevations greater than 6,000 feet).

Students should note the factors of high altitude flight and make sure they are proficient at calculating Pressure Altitude and Density Altitude before this demonstration so that their understanding of the principle will be greater.

Use Cessna 172 (no fixed-pitched propeller or turbo charged engine).

Discuss the aspects of high altitude flight from previous slide and provide them with a thorough understanding of what might happen in thin air flight where air density is less. Teach not just altitude but warmer air is also thinner air.

Have a short class discussion of what the airplane wing might do in thin air.
AIRCRAFT LOCATION

ON THE GROUND

SEARCH

SELECT AN AIRPLANE: Cessna Skyhawk 172SP

SELECT AN AIRPORT: KBTM Mooney, Butte, Montana

SELECT A RUNWAY: 16
• Using the simulator, have students first fly in glide mode, 75 knots, 10 miles out from the selected high altitude airport.
• Glide toward the selected airport (but without landing) first from altitude of 10,000, then a second trial from 6000 feet.
• Have co-pilot or a student take data on the sound of the aircraft, the airspeed indicator, RPM’s
• Maintain a 75 knot glide, the second student clocks the glide for each 1000 feet of descent during the altitude reduction. (Might need two timers)
• HAVE STUDENT PAY PARTICULAR ATTENTION TO AIRSPEED INDICATOR READINGS ON BOTH GLIDES FROM THE ALTITUDES SELECTED
• INDICATE TO STUDENTS THAT AIRSPEED WOULD ACTUALLY BE 10% GREATER (THIN AIR) BUT NOT BE REPRESENTED ON AIRSPEED INDICATOR
• EXPLAIN....... THE THINNER AIR, LESS FRICTION, GREATER GLIDE WILL NOT MEASURE ON THE AIRSPEED INDICATOR. NO PRESSURE DIFFERENCE ON THE PITOT TUBE ONLY A LIFT DIFFERENCE ON THE WINGS
Have students repeat this flight but select a temperature at the airport under weather conditions to be hotter than 100 degrees F. Then also select a different temperature to complete this glide flight, perhaps 32 degrees F.

HAVE STUDENTS NOTE IF THERE ARE ANY DIFFERENCES IN THE AIR SPEED INDICATOR?
EXPLAIN THAT THE AIRSPEED, DUE TO HOT AIR, WILL ALSO PROVIDE A 5% INCREASE IN AIRSPEED, SO COMBINED ALTITUDE AND WARM TEMPERATURE CAN PROVIDE AS MUCH AS 15% GREATER AIRSPEED ON GLIDE BUT WITHOUT DETECTION BY THE AIRSPEED INDICATOR.

EXPLAIN THE PITOT TUBE IS REGISTERING THE SAME AIR AS THE WINGS (BOTH THIN AND WARM) BUT IS NOT AFFECTED BY THE ABSENCE OF THE LIFT FORCES
High Altitude Glide Path into Butte Montana
A GOOD OPPORTUNITY TO RE-OPEN THE DIALOGUE ON LIFT AND DRAG

EXPLAIN TO STUDENTS THAT THINNER AIR MOLECULES RESULT IN LESS LIFT AT THE WING AND THE AIRPLANE WOULD HAVE LESS OVERALL LIFT. BUT IF THE AIR IS THINNER THERE IS ALSO LESS DRAG LESS DRAG = MORE THRUST EQUAL AND OPPOSING PHYSICS FORCES ISAAC NEWTON.......?
Note the airspeed Indicator and how slow we can get at this altitude with thin air and less drag/more thrust
PHYSICS/SIM........DEMONSTRATION # 5
LANDING AT HIGH ALTITUDE AND WARM TEMPERATURES

Following the high altitude glide demonstration have students prepare to land at one of the high altitude airports they selected (5,000 feet or greater) and repeat at a “sea-level” airport. Have your “DATA TAKING STUDENT” record information on airspeed, time of glide per 1000 feet descent at 75 knots, noting any landing effects they can see. Students need to be proficient at replaying the flight in the data or graph mode to gain a better understanding. Repeat discussion regarding the increased airspeed at high altitude and warmer temps providing a combined increased airspeed of 15% and while they might not have an airspeed reading indicating this... what might happen upon landing and even takeoff with regard to distance?
EXPLAIN TO STUDENTS LANDING EFFECTS SUCH AS GROUND EFFECT, FLOATING OVER THE RUNWAY ETC. MIGHT FEEL THE SAME BETWEEN THE HIGH ALTITUDE LANDING AND A “SEA-LEVEL” LANDING

THERE MAY BE A SLIGHT SENSITIVITY TO THE FLIGHT CONTROLS AT HIGHER ALTITUDE BECAUSE OF THE LESS DENSE AIR.

UPON LANDING THE STUDENT SHOULD NOTE THE EFFECT AND THE GRAPH SHOULD REPRESENT THE EFFECTS

Longer roll, more ground effect, need to flare more
LANDING AT HIGH ALTITUDE (>4,000 Ft) SHOULD REQUIRE 1/3 ADDITIONAL RUNWAY THAN AT “SEA-LEVEL”

OPEN THE DISCUSSION THAT, JUST LIKE THE LANDING IN HIGH ALTITUDE, WHILE THE AIRSPEED INDICATOR DID NOT SHOW GREATER AIRSPEED THE LANDING DISTANCE WILL!
Takeoff due to high altitude and warm temp.

Have students take off and land with the same RPM’s, same Vy or Vx and aircraft both at “sea-level” altitude and at a high altitude airport. Students should note the difference due to “roll out”. This difference would not show up on the altitude indicator but the need for a longer runway length would be apparent.

Make sure the runways are of equal construction. A grass field would have increase drag over concrete or asphalt and affect the data.
Mountain flying
Repeat this demonstration with the students flying at high altitude and warmer temperatures but just below a mountain range with the intent to cross the mountain range with a 10 mile approach in front of the mountain range and expect to climb up to 6,000 feet.

Fly at the same airspeed and RPM’s for the climb and determine if the student can make it over the range?

A GOOD TIME TO POINT OUT THAT THE AIRSPEED INDICATOR MIGHT BE OFF BY 15% (because of thin air) AND YOU DON’T REALIZE IT. ANOTHER GOOD TIME TO EXPLAIN THE NEED TO FLY OVER MOUNTAINS AT AN ANGLE RATHER THAN PERPENDICULAR.
Teach students about thin air and mountain flying. Where would be the proper place to cross the mountains? Perhaps fly at an angle to them to gain altitude.
PHYSICS/SIM.......DEMONSTRATION # 8
LISTEN TO YOUR AIRCRAFT

This is a simple but effective and educational demo. You will need speakers on your simulators (Cheap plug-in speakers work well).

• Turn sound up LOUD ON THE SIM SPEAKERS.
• Ask two students to participate. One pilots, the other listens to the sounds (participants can switch).
• Take off and obtain level flight and record the Knots /RPM
• Move throttle to 2000 rpm, 0 wind setting, record airspeed, listen to the sound for a minute
• Reduce the rpms by 50 each time, note airspeed and listen
Please note that the limit of normal operating range for Cessna 172 is 2600 rpm. Reinforce this with students. Have students practice this “resonance” of sound which is a good indicator of airspeed. All pilots need to be able to hear their aircraft sound, not just rely on instruments. THIS IS A BASIC PHYSICS PRINCIPLE OF SOUND RESONANCE

After multiple tries at each reduction of 50 RPM intervals, listen to the sounds as you prepare for landing.
Have students listen, and go over the landing speeds and rpms. THEY DO NOT HAVE TO BE PROFICIENT AT LANDING DURING THIS STEP OF SIMULATION

- 85 knots (listen to the rpm’s) “downwind”
- 75 knots (listen to the rpm’s) “base”
- 65 knots (listen to the rpm’s) “final and landing”

You might have to refresh their memory of “slow flight” for the 65 knots and if you are simulating landing, the 65 probably should be throttle out.
Einstein’s Theory of Relativity states time and motion are relative to a person’s location viewing another object.

Example 1: A person on a train with the windows closed and negating the motion of the train does not know the direction of the train.

Example 2: The same is true of an airplane motion in the wind. The airspeed indicator simply registers the airspeed of the propeller pulling the airplane in the air.
A balloon and rider in the basket below will be in the effect of the drift of the balloon. If the balloon is drifting at 60 miles per hour, the person in the balloon does not feel the 60 mile per hour wind. He is moving at the same speed as the balloon and the wind. IN EFFECT HE IS “IN IT”
Suppose you are flying north and a 20 mph wind is blowing from the west; your flight is 100 mph by throttle rpm’s. Where will you be in ¼ hour. You will be 25 miles north and 5 miles more east of where you wanted to be.

**WHAT DO YOU DO ON A SIMULATOR OR IN THE AIR TO RESOLVE THIS?**

A student pilot might right rudder to stop the “crab”. This will merely yaw the plane to the left and make the crab worse.
The student pilot might use right aileron. Now he will cancel all his flight vectors and directions of yaw. TO COUNTER THE DRIFT HE NEEDS NO CONTROLS

SIMULATOR RESOLUTION: Teach that vectors are relative to position that needs only flight corrections not instructional corrections. This would be a good time to teach and demonstrate the physics lesson of vector analysis and flying both by time and destination to counter the wind angle.
OVERALL THE AIRCRAFT IS A HORRIBLE CLASSROOM BUT SOONER OR LATER IT IS WHERE WE HAVE TO LEARN TO FLY

WORK WITH YOUR LOCAL AIRPORT TO SUPPORT AVIATION EDUCATION WITH OUR YOUTH. YOU WILL BE SURPRISED AT HOW THEY WILL HELP YOU.
MAKE A FLIGHT TRAINING PARTNERSHIP WITH A FLIGHT SCHOOL

- Texas Aviation Academy, based out of New Braunfels, Texas, provides flight training out of Karnes County Airport to support the KCISD aviation curriculum.

- While small towns are unlikely to support a full time flight school, a partnership with a larger operation that is willing to base one or more of their aircraft at your airport is key to providing opportunities for students after school to train.

OUR PARTNERS IN STUDENT FLIGHT TRAINING
HOW DO YOU SUCCEED WITH AVIATION PROGRAMS IN YOUR SCHOOL

• Get “buy in” from your school board first. “I’m ready to go up right now,” said one KCISD Board member when Purser outlined his proposed course.

“Aviation Program Could Take Flight For Karnes City Soon”
AVIATION PHYSICS DEMOS YOU CAN GET THE CLASS

Simple Plastic Airplane, show the wing design
Funnel and small ball- faster-Low Pressure; slower- High Pressure or lift
Make a wing out of toilet paper- airflow and lift
Bernoulli Bag- fast moving air, low pressure into the bag draws more air with it
Balloons in Bottle- pressure of air is like a vacuum and keeps the wing up or the balloon inflated.

Slit in the cup vs no slit; balloon – if air escapes and cannot move faster around a curved surface no lift
Twin Balloons- air movement creates negative pressure and will pull the balloons in; same effect happens while passing trucks or boats. Can use soda cans on a string.

Save the Best for Last – the leaf blower and the balls. Students think the balls are held with a Push not a Pull....... Show them it is a pull.

EMAIL ME IF YOU WANT THESE PHYSICS DEMO’S IN YOUR CLASS. I WILL BE HAPPY TO SEND YOU INSTRUCTIONS FOR THEM.

DPURSER@KCISD.NET 210-317-7300
Make sure you have a ticket and you tear it in half. Place half of the ticket in the bowl for the drawing for your Own copy of “Stick and Rudder” Best book for any aviation related flight dynamics