INCORPORATING THE EDUSTATION FLIGHT SIMULATOR ACTIVITIES IN MATH AND SCIENCE LESSONS AND IN AEROSPACE-THEMED CLASSES

Notes:
1. Before doing math or science lessons with flight simulators, first fly aerospace lessons 1 through 6 to give students a basic concept of flight.
2. The following math and science lessons are just some of those that are possible to do—teachers could develop many more lessons on many different topics.

Using Edustation Flight Simulators in Math Lessons:

Math Lesson	*Complementary Flight Simulator Activity*	*Sample of Common Core Math Standards Met by Activity*
Measurement (inquiry lesson)	Opening: Look at the airplane's instrument panel – what do you see? Learning Target: I can fly the flight simulator profile and measure several variables. Main activity: Students discuss what they think they can measure and what the units will be; students fly the flight simulator while non-flying group members measure different variables of their choice; students explain how they are measuring and what the variables mean; students present their results to the class and discuss them; (consider optional follow on lesson on units of measure).	5.MD.A.1 5.MD.B.2 HSN-Q.A.1 HSN-Q.A.2 HSN-Q.A.3
Rate of change (inquiry lesson)	Opening: What are some rates of change that occur as an airplane flies? Learning Target: I can fly the flight simulator profile and measure several rates of change. Main activity: Students discuss what they think they can measure and what the units will be; students fly the flight simulator while non-flying group members measure different variables of their choice while also measuring the time; students explain how they are measuring and what the variables mean; students calculate the rates of change they measured; students present their results to the class and discuss them.	8.EE.B.5 8.EE.B.6 8.F.B.4 8.F.B.5
Arithmetic series	Opening: If an airplane is traveling at a constant speed of 120 MPH, how far would it go in 1 hour? 2 hours? How do we know this?	HSA-SSE.A.1 HSA-SSE.A.1a HSA-SSE.A.1b

	Learning Target: I can fly the flight simulator profile and see how a constant rate results in an arithmetic series. Main activity: Students discuss rate and constant rate; students take off in the flight simulator, climb to altitude, then set up a constant speed cruise and measure the distance (use DME or map feature) at equal time intervals; students record the data and note how the series is arithmetic; students write a recursive rule for the series and discuss how this could be useful.	
Geometric series	Opening: If an airplane is taking off, what happens to its speed? Learning Target: I can fly the flight simulator profile and see how acceleration relates to a geometric series. Main activity: Students discuss rate and changing rate; students perform a take off in the flight simulator, noting the airspeed at equal time intervals from brake release to liftoff; students record the data and note how the series is geometric; students write a recursive rule for the series and discuss how this could be useful.	HSA-SSE.A.1 HSA-SSE.A.1a HSA-SSE.A.1b HSA-SSE.B.4
Linear functions (inquiry lesson)	Opening: What airplane performance variables might show linearity? Learning Target: I can fly the flight simulator profile and measure many variables on an airplane and determine if they are linear. Main activity: Students discuss what they think they can measure and which might be linear; students fly the flight simulator while non-flying group members measure different variables of their choice; students explain how they are measuring and what the variables mean; students check to see if the variables demonstrate linearity by graphing them; students find a function to represent any linear relationships; students present their results to the class and discuss them.	8.F.B.4 8.F.B.5 HSA-CED.A.1 HSA-CED.A.2 HSA-CED.A.3 HSA-CED.A.4
Slope	Opening: What airplane performance variable might relate to slope? Learning Target: I can fly the flight simulator profile and measure climb rate to determine slope. Main activity: Students discuss the concept of slope of a linear function; students discuss how climb rate would show slope; students determine what to measure on a climb to figure the slope (altitude vs. time); students take off and measure the airplane's altitude at set intervals while also	HSA-CED.A.1 HSA-CED.A.2 HSA-CED.A.3 HSA-CED.A.4

	recording the vertical speed; students plot the altitude as a function of time on a graph and measure the slope, then compare the calculation to the vertical speed; students discuss the results.	
Data analysis – best fit	<u>Opening</u>: You are in a flight test organization, and you are tasked with determining a new airplane's climb rate – how will you measure it? <u>Learning Target</u>: I can fly the flight simulator profile and determine climb rate from data I get using best fit. <u>Main activity</u>: Students discuss the concept of linearity and best fit; students discuss how they would measure climb rate using several trials, understanding that each trial will give slightly different data due to human factors (different flying technique on each climb); students fly several climb profiles as closely the same as possible—same aircraft and conditions, same airspeed, same climb profile; students plot each climb's data points (altitude vs. time); students note how the data is a scatter plot showing linearity; students use graphing calculators and their eyes to plot best fit of the data; students discuss the results.	HSF-BF.A.1 HSF-BF.A.1a
Statistics – mean, median, mode	<u>Opening</u>: Look at the previous lesson on best fit – could we use the data to find one climb rate? <u>Learning Target</u>: I can fly the flight simulator profile and get data to calculate mean, median and mode. <u>Main activity</u>: Students discuss the previous lesson where they performed several climbs and plotted the data from each to find the best fit; the students use the data to calculate the climb rate of each climb; the students discuss central tendency, then how they can calculate mean, median, and mode for the climb rate; students calculate mean, median, and mode, then compare the results to the best fit line.	HSS-ID.A.1 HSS-ID.A.2 HSS-ID.A.3 HSS-ID.A.4
Trigonometry – calculating a descent gradient	<u>Opening</u>: You are a 747 airline captain flying to JFK airport from London—you are cruising at 39,000 feet—at what distance from JFK do you need to start to descend for a comfortable/normal descent? <u>Learning Target</u>: I can fly the flight simulator profile and use trigonometric relationships to calculate a descent gradient. <u>Main activity</u>: Students review trigonometric relationships; students think about the descent problem; students plot the airplane on a graph,	HS-SRT.C.6 HS-SRT.C.7 HS-SRT.C.8

	39,000 feet up and an unknown distance from JFK—a comfortable descent is at 3 degrees nose down; students use tangent to calculate the distance from the airport to start descent; students fly the profile in the simulator to test it; students experiment with higher and lower angles (calculating distance, then measuring it) to see how they work; students discuss the results.	
Law of cosines	Opening: How does a crosswind affect an airplane's route of flight? Learning Target: I can calculate the effect of a crosswind using the law of cosines. Main activity: Students discuss how a crosswind would affect an airplane's route of flight; students understand that a 90 degree crosswind makes a right triangle so the Pythagorean Theorem could be used to find the resultant route; students learn the law of cosines, then calculate the route with information given; students test their calculation by flying the same route with the same crosswind; students compare the flight results with the calculations.	HS-SRT.D.10 HS-SRT.D.11
Area versus Length of a Square	Opening: How would you use an airplane to search for someone lost in the desert? Learning Target: I can fly the flight simulator profile and compare length and area. Main activity: Students discuss how they would fly a search pattern; students learn that one way is to fly a square spiral flightpath from the lost person's last known position – one way to fly this profile is to have students start from at 1000 feet over an airport with DME and fly north, then turn 90 degrees left after 30 seconds, then turn again after 30 seconds, then turn after 60 seconds, then again after 60 seconds, then turn after 90 seconds, then again after 90 seconds, etc., until the DME reads 5 miles (making a 10 mile by 10 mile square), and time how long it takes; then students repeat the search out to 10 miles on the DME from the airport (making a 20 mile by 20 mile square), and time how long it takes; students graph both searches, measuring lengths of search and total area searched; students conclude that twice the length caused four times the area; students develop function for length vs. area of a square.	7.G.B.6 HS-G.MG.1 HS-G.MG.3

Using triangulation to fix a position in space	Opening: How can a pilot use landmarks or radio navigation aids to most precisely determine the airplane's position if he/she cannot fly directly over them? Learning Target: I can fly the flight simulator profile and fix my position using triangulation. Main activity: Students discuss how a pilot can determine, or fix, his or her position in space most accurately using distant landmarks or radio navigation aids; students learn how one landmark gives a bearing, but not a distance, so it only provides a line along which the airplane could be, but two landmarks give a crossing point, and three or more landmarks give the best accuracy for the crossing point—using three is called triangulation (ask students why); students relate this concept to how the GPS navigation system works; students fly the flight simulator and preplan to fly over an airport where there are three nearby radio navigation aids; students predict the bearings to each radio navigation aid, then verify these in flight; students draw conclusions.	8.GA.5 HS-G.CO.9 HS-G.CO.10
Great circle routes	Opening: What is the flight path of an airliner traveling from New York to London, and why does it follow this path? Learning Target: I can fly the flight simulator profile and explain why a great circle route is the shortest distance between two points on the globe. Main activity: Students discuss how airliners fly over the Atlantic; students learn that the airliners fly far to the north as they cross the ocean, not "straight" across on a constant heading; students use a globe to find the shortest distance between two points, such as New York and London, using a piece of string and see that the shortest path appears curved; students research to find out why and learn that the shortest path is a circle centered on the center of the globe (great circle) and that the equator is an example; students fly a sped-up profile from New York to London going "straight" (constant heading) and another profile following a great circle route, then compare the distance and time flown.	8.GC.9 HS-G.C.5 HS-G.GMD.1

Using Edustation Flight Simulators in Science Lessons:

Science Lesson	*Complementary Flight Simulator Activity*	*Next Generation Science Standards Met by Activity*	
		Middle School	*High School*
Motion (inquiry lesson)	Opening: How can we measure the motion of an object? Learning Target: I can complete the profile on the flight simulator and measure the airplane's motion. Main activity: Students review what they have learned about motion, then apply this to flight; students explain what they expect to see when the airplane takes off, climbs up to altitude, cruises, descends, and lands; students think of what they could measure; students fly the profile and make measurements, perhaps using the map mode to see the airplane's track, as well as the flight mode; students note how the airplane moves horizontally and vertically; students discuss what they learned.	MS-PS2-2 MS-PS3-5 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-PS2-1 HS-PS2-2 HS-ETS1-2
Speed	Opening: What is "speed?" Learning Target: I can complete the profile on the flight simulator and calculate the speed on takeoff and in level flight. Main activity: PART 1: Students review what they have learned about speed and velocity, then apply this to flight; students explain what they expect to see, then perform a takeoff while measuring the airplane's time and distance to calculate its speed from brake release to liftoff, comparing this to the airspeed indicator; students discuss the difference between average speed and indicated (instantaneous) speed. PART 2: Students climb to altitude and cruise in level flight, measuring the airplane's distance (using DME or map feature) and time to calculate its speed, then compare this to the indicated airspeed—students discuss possible reasons for any difference.	MS-PS2-2 MS-PS2-4 MS-PS3-1 MS-PS3-5	HS-PS2-1 HS-PS2-2
Acceleration	Opening: When is an object accelerating? Learning Target: I can complete the profile on the flight simulator and calculate the acceleration on takeoff and inflight. Main activity: PART 1: Students review what they have learned about acceleration, then apply this to flight; students explain what they expect to see, then perform a takeoff while measuring the airplane's indicated	MS-PS2-2 MS-PS2-4 MS-PS3-1 MS-PS3-5	HS-PS2-1 HS-PS2-2

	airspeed at different time intervals to calculate acceleration. PART 2: Students climb to altitude and cruise in level flight, measuring the airplane's indicated airspeed; students turn the airplane and note that a force is required to change direction; students speed up or slow down and note that a force is required to do either; students discuss the difference between speed and velocity and what a change in velocity is; students calculate the acceleration for each situation; students discuss what they learned.		
Force	Opening: What forces are acting on an airplane? Learning Target: I can complete the profile on the flight simulator and calculate the net force on an airplane during takeoff. Main activity: Students review what they have learned about force and net force, then apply this to flight; students learn about the four forces of flight; students understand that the net force on takeoff is the difference between the thrust and drag, both aerodynamic and from the tires; students hypothesize what the net force will be; students perform a takeoff and measure the airplane's acceleration (see previous lesson); students use the airplane's acceleration and mass to calculate the net force; students use the published engine thrust and calculated net force to calculate what the drag is; (optional follow-on activity) students brainstorm ways to reduce this drag and understand how this will affect fuel consumption.	MS-PS2-1 MS-PS2-2 MS-PS2-4 MS-PS3-1 MS-PS3-5	HS-PS2-1 HS-PS2-2 HS-PS2-3 HS-PS2-4
Newton's Laws of Motion	Opening: Who was Isaac Newton and when did he live? Learning Target: I can complete the profile on the flight simulator and demonstrate each of Newton's Laws of Motion. Main activity: (Inquiry option) Students start the flight simulator with the airplane on the runway, throttles at idle—students understand the airplane will not move unless the throttle is pushed up; students push up the throttle and get the airplane to begin rolling down the runway—students understand the airplane will not stop unless the throttle is reduced and brakes applied; students start over and take off, measuring the acceleration at full throttle; students start over and take off with throttle at 80% power while measuring acceleration; students compare	MS-PS2-1 MS-PS2-2 MS-PS2-4 MS-PS3-1 MS-PS3-5 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-PS2-1 HS-PS2-2 HS-PS2-3 HS-PS2-4 HS-ETS1-2 HS-ETS1-4

	the takeoffs and relate the acceleration to thrust; students explain how the propeller or jet engine works and understand that the mass of air being pushed backward makes the airplane go forward; student review Newton's laws of motion and relate these to what they have just seen. (Design option) students learn about Newton's laws of motion, then are told to design a demonstration using the flight simulator for each law; students come up with the demonstrations and practice them, refining as needed; students present their demonstrations to the class.		
Relative velocity	Opening: What is a practical situation where a pilot is concerned with relative velocity? Learning Target: I can complete the profile on the flight simulator and calculate an airplane's relative velocity. Main activity: Students review what they have learned about relative velocity, then apply this to flight; students explain how an airplane is affected by the wind; students are given a flight profile to fly 30 miles on a heading with a 90 degree crosswind of 30 knots, then to calculate the relative velocity; students fly the simulator profile (preprogrammed with the wind data just given); students note the indicated airspeed while cruising the 30 miles, then calculate the actual (relative) velocity based on the distance traveled and time elapsed; students discuss what they learned and if the data matched their expectations.	MS-PS2-1 MS-PS2-2 MS-PS2-4 MS-PS3-1 MS-PS3-5	HS-PS2-1 HS-PS2-2
Centripetal acceleration	Opening: What is "G" force? Learning Target: I can complete the profile on the flight simulator and calculate an airplane's centripetal acceleration at various bank angles. Main activity: Students review how an airplane turns; students relate an airplane in a turn to an object moving in a circle; students relate bank angle to turn radius and rate of turn; students fly the flight simulator in level flight, then turn for 180 degrees while holding a specific bank angle and airspeed; students collect data for many bank angles (e.g., 20, 30, 40, 50, and 60 degrees of bank); students measure the airplane's time to complete the 180 degree turn and the accelerometer reading; students may also measure the radius of turn (using map feature); students calculate the centripetal acceleration and discuss the results.	MS-PS2-1 MS-PS2-2 MS-PS2-4 MS-PS3-1 MS-PS3-5	HS-PS2-1 HS-PS2-2

Momentum	<u>Opening</u>: What is "momentum?" <u>Learning Target</u>: I can complete the profile on the flight simulator and calculate an airplane's momentum on landing, and understand how momentum relates to stopping distance. <u>Main activity</u>: Students review what they have learned about momentum, then apply this to flight; students explain how an airplane has momentum and how to calculate it; students fly a given airplane multiple times on the same approach and landing, but vary the landing airspeed, noting how long the pilot has to apply brakes and how far the airplane travels to stop; students use the landing airspeed to calculate the airplane's momentum at each touchdown and see how these momentum values relate to braking time and stopping distance (also can graph these values).	MS-PS2-1 MS-PS2-2 MS-PS2-4 MS-PS3-1 MS-PS3-5	HS-PS2-1 HS-PS2-2 HS-PS2-3 HS-PS2-4
Mechanical energy	<u>Opening</u>: How much kinetic energy (KE) and potential energy (PE) does an airplane have when it's flying? <u>Learning Target</u>: I can complete the profile on the flight simulator and calculate an airplane's KE and PE on takeoff, inflight, and on landing. <u>Main activity</u>: Students review what they have learned about KE and PE, then apply this to flight; students explain where the airplane's energy comes from (fuel energy) and how this is converted to mechanical KE and PE; students get directions for sim lesson (worksheet); students fly a takeoff and calculate KE and PE at liftoff, then fly to 35,000 feet and calculate KE and PE, then descend and land and calculate KE and PE at touchdown; students account for where the energy came from and where it went as they do each maneuver, then discuss what they learned. Consider follow on lesson about braking energy and stopping distance.	MS-PS2-1 MS-PS2-2 MS-PS2-4 MS-PS3-1 MS-PS3-2 MS-PS3-3 MS-PS3-4 MS-PS3-5	HS-PS2-1 HS-PS2-2 HS-PS2-3 HS-PS2-4 HS-PS3-1 HS-PS3-2 HS-PS3-3
Conservation of energy	<u>Opening</u>: How does a pilot control an airplane's kinetic energy (KE) and potential energy (PE)? <u>Learning Target</u>: I can complete the profile on the flight simulator and determine if energy is conserved in flight. <u>Main activity</u>: Students review what they have learned about KE and PE, then apply this to flight; students explain where the airplane's energy comes from (fuel energy) and how this is converted to mechanical KE and PE; students get directions for sim lesson (worksheet); students fly a	MS-PS1-4 MS-PS2-1 MS-PS2-2 MS-PS2-4 MS-PS3-1 MS-PS3-2 MS-PS3-3 MS-PS3-4	HS-PS2-1 HS-PS2-2 HS-PS2-3 HS-PS2-4 HS-PS3-1 HS-PS3-2 HS-PS3-3

	simulated energy profile; students account for where the energy came from and where it went as they do each maneuver, then discuss what they learned.	MS-PS3-5	
Power	Opening: How do airplanes compare on their power? Learning Target: I can complete the profile on the flight simulator and compare the power of different airplanes. Main activity: Students review the concept of power, then apply this to flight; students explain where power comes from in an airplane and how it can be measured and compared; students get directions for sim lesson (worksheet); students fly a series of takeoffs in different airplanes and calculate the power for each one; students compare airplane performances and discuss what they learned.	MS-PS1-4 MS-PS2-1 MS-PS2-2 MS-PS2-4 MS-PS3-1 MS-PS3-2 MS-PS3-3 MS-PS3-4 MS-PS3-5	HS-PS2-1 HS-PS2-2 HS-PS2-3 HS-PS2-4 HS-PS3-1 HS-PS3-2 HS-PS3-3 HS-PS3-4
Mechanical efficiency	Opening: How could we measure the efficiency of an airplane? Learning Target: I can complete the profile on the flight simulator and calculate mechanical efficiency of an airplane. Main activity: Students review the concept of mechanical efficiency and how to calculate it; students plan a simple airplane flight using a jet aircraft with engines whose thrust is known; students note the amount of fuel consumed, then calculate the energy in that fuel; students calculate the work done by the airplane as thrust x distance; students compare work done with energy consumed and discuss where the rest of the fuel energy went and what they learned.	MS-PS2-1 MS-PS2-2 MS-PS2-4 MS-PS3-1 MS-PS3-2 MS-PS3-3 MS-PS3-4 MS-PS3-5 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-PS2-1 HS-PS2-2 HS-PS2-3 HS-PS2-4 HS-PS3-1 HS-PS3-2 HS-PS3-3 HS-ETS1-1 HS-ETS1-2 HS-ETS1-3 HS-ETS1-4
Simple machines (ramp) and mechanical advantage	Opening: What does a simple machine do for us? Learning Target: I can complete the profile on the flight simulator and calculate the mechanical advantage of an airplane's climb to altitude. Main activity: Students review the concept of mechanical advantage, how it relates to a ramp, and how to calculate it; students discuss how an airplane on climb out is like a weight going up a ramp; students start the flight simulator and note the takeoff weight of the airplane being flown; students takeoff and climb while noting the pitch (angle upward in degrees); students also note the distance traveled between liftoff and a	MS-PS2-1 MS-PS2-2 MS-PS2-4 MS-PS3-1 MS-PS3-2 MS-PS3-3 MS-PS3-4 MS-PS3-5	HS-PS2-1 HS-PS2-2 HS-PS2-3 HS-PS2-4 HS-PS3-1 HS-PS3-2 HS-PS3-3 HS-ETS1-1 HS-ETS1-2

	designated final point at altitude; students calculate the work required to lift the airplane straight up to altitude, then calculate the work done flying to altitude (need the net force – see earlier lesson for this); students compare the two work values and calculate the mechanical advantage; students discuss their results.	MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-ETS1-3 HS-ETS1-4
Circular motion	<u>Opening</u>: How does a pilot fly a loop? <u>Learning Target</u>: I can complete the profile on the flight simulator and calculate the centripetal acceleration and centrifugal "force" or "G force." <u>Main activity</u>: Students discuss and learn how pilots fly loops and other aerobatics; students review the concept of circular motion, relating tangential speed, radius of the circle, and centripetal acceleration, then relate this to the equal and opposite centrifugal or "G" force which the pilot feels; students fly the simulator and perform a loop in an aerobatic airplane, such as the F/A-18 (start at 10,000 feet, level flight, 400 KIAS), first pulling 4G's on the accelerometer, then fly a second loop pulling 6 G's, and noting the altitude required (diameter of the loop); students explain what they found and see how more G's caused a tighter, smaller loop.	MS-PS2-1 MS-PS2-2 MS-PS2-4 MS-PS3-1 MS-PS3-5	HS-PS2-1 HS-PS2-2 HS-PS3-2
Torque	<u>Opening</u>: Can an airliner fly if one of the engines fails? How does the pilot fly the airplane? <u>Learning Target</u>: I can complete the profile on the flight simulator and relate torque to the force applied and the distance from center that the force is applied. <u>Main activity</u>: Students learn how multi-engine airplanes are designed to fly safely with one engine out; students review the concept of torque, or twisting force, and relate it to force and distance from center (radius); students fly a 747 on takeoff and fail an inboard engine (#2) at 120 KIAS and continue the takeoff, then they fly another takeoff where an outboard engine (#1) is failed at 120 KIAS; students note how much harder it is to keep the airplane rolling straight on takeoff with an outboard engine failure; students relate this experience to the torque, then calculate what the torque is in each situation using the thrust and dimensions of a 747.	MS-PS2-1 MS-PS2-2 MS-PS2-4 MS-PS3-1 MS-PS3-5	HS-PS2-1 HS-PS2-2 HS-PS3-2
Microgravity or weightlessness	<u>Opening</u>: What is microgravity? Why not call it zero gravity?	MS-PS2-1 MS-PS2-2	HS-PS2-1 HS-PS2-2

	Learning Target: I can complete the profile on the flight simulator and demonstrate how to fly a microgravity profile. Main activity: Students discuss microgravity and relate it to the NASA flight trainer for astronauts (the "Vomit Comet"); students figure out how they could fly a microgravity flight profile (fly upward, then slowly push over at 0 G on the accelerometer, then recover when in a shallow dive); students learn that NASA flies the Vomit Comet through dozens of such parabolic flight paths each sortie to train astronauts for microgravity in space; students fly the profile in the flight simulator and see what issues might arise (e.g., end up in too steep a dive); students discuss findings.	MS-PS2-4 MS-PS3-1 MS-PS3-5	HS-PS3-2

Using Edustation Flight Simulators in Aerospace-themed Classes:

Aerospace Lesson	*Complementary Flight Simulator Activity*	*Next Generation Science Standards Met by Activity*	
		Middle School	*High School*
1. Introduction to flying – basics of airplane, cockpit familiarization	Edustation Mission 1	MS-ETS1-2	HS-ETS1-2
2. How to fly straight and level and turn (inquiry lesson)	<u>Opening</u>: Start your flight simulators to be at 2000 feet altitude, 100 KIAS, level flight. <u>Learning Target</u>: I can use the yoke and rudder pedals to fly straight and level and make turns right and left. <u>Main activity</u>: Students discuss how they think the yoke and rudder pedals and throttle all work; students get worksheets to guide them through flight sim profile; students fly profile where they attempt to fly straight and level and to turn; students discuss what they observed and what they think was happening.	MS-PS2-1 MS-PS2-2 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4 (NOTE: While students are not designing an object, they are using a systematic design process to understand how to fly by using flight controls as tools.)	HS-PS2-1 HS-PS2-2 HS-ETS1-2
3. How primary flight controls work	<u>Opening</u>: What is Newton's Third Law of motion? How would it apply to how an airplane is controlled? <u>Learning Target</u>: I can use the primary flight controls properly and explain how they work. <u>Main activity</u>: Students discuss secondary flight control systems; students get worksheets to guide them through flight sim profile; students fly profile.	MS-PS2-1 MS-PS2-2 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-PS2-1 HS-PS2-2 HS-ETS1-2
4. How to takeoff and climb	Edustation Mission 3	MS-PS2-1 MS-PS2-2 MS-PS3-1 MS-PS3-5 MS-ETS1-1 MS-ETS1-2	HS-PS2-1 HS-PS2-2 HS-PS3-1 HS-PS3-3 HS-ETS1-2

		MS-ETS1-3 MS-ETS1-4	
5. How secondary flight controls work	Opening: How could we slow down for landing more easily? Learning Target: I can fly an airplane and use secondary flight controls by using flaps, slats, air brakes properly and explaining how they work. Main activity: Students discuss secondary flight control systems; students get worksheets to guide them through flight sim profile; students fly profile.	MS-PS2-1 MS-PS2-2 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-PS2-1 HS-PS2-2 HS-PS2-3 HS-ETS1-2
6. How to descend and land	Edustation Mission 4	MS-PS2-1 MS-PS2-2 MS-PS3-1 MS-PS3-5 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-PS2-1 HS-PS2-2 HS-PS3-1 HS-PS3-3 HS-ETS1-2
7. How to fly using instruments	Edustation Mission 2	MSPS4-2 MS-ESS2-5 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-PS4-1 HS-PS4-2 HS-PS4-3 HS-PS4-4 HS-PS4-5 HS-ETS1-2
8. How to fly a visual or instrument traffic pattern	Edustation Missions 5 & 7	MSPS4-2 MS-ESS2-5 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-PS4-1 HS-PS4-2 HS-PS4-3 HS-PS4-4 HS-PS4-5 HS-ETS1-2
9. How to fly an instrument approach	Edustation Mission 9	MS-PS4-2 MS-ESS2-5 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3	HS-PS4-1 HS-PS4-2 HS-PS4-3 HS-PS4-4 HS-PS4-5

		MS-ETS1-4	HS-ETS1-2
10. How to fly in an emergency	Edustation Mission 8	MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-ETS1-2
11. How to navigate – using a compass	Opening: How do you think pilots fly using a compass? Learning Target: I can fly an airplane on a heading and on a course using a compass inflight. Main activity: Students learn how pilots use instruments to fly a heading and a course; students practice heading and course control on the flight simulator; students see problems with airplane's magnetic compass (lead and lag) and advantage to gyro-controlled heading indicator.	MS-PS2-3 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-ESS2-1 HS-ETS1-2
12. How to navigate – basic pilotage and dead reckoning	Opening: What is a map? Learning Target: I can fly the flight simulator profile and practice using a map to navigate. Main activity: Students learn how to read and use a map; students look at road maps, hiking maps, and aeronautical maps; students fly the flight simulator and practice map navigation (pilotage) flying from Brainard Airport, down the Connecticut River to Groton-New London Airport; students discuss what they learned. Follow on lesson(s) using map and compass.	MS-ESS2-2 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-ESS2-1 HS-ETS1-2
13. How to fly cross country	Edustation Mission 6	MS-ESS2-2 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-ESS2-1 HS-ETS1-2
	FOLLOW ON LESSONS TO EXPLORE ASPECTS OF AERONAUTICS		
14. How gliders compare to airplanes	Opening: What is "gliding" and how is it different than flying? Learning Target: I can fly best glide speed in several airplanes.	MS-PS2-1 MS-PS2-2 MS-PS2-4	HS-PS2-1 HS-PS2-2 HS-PS3-1

	Main activity: Students review what they have learned about best glide speed (lesson done in class or given as reading assignment); students get directions for sim lesson (worksheet); students fly a glider; students fly several airplanes without power and at best glide speed; students discuss how gliding is different than powered flight and how glider design is different than airplane design.	MS-PS3-1 MS-PS3-2 MS-PS3-5 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-PS3-3 HS-ETS1-2
15. How aircraft are tested	Opening: What is an example of a flight test? Learning Target: I can complete the flight test profile on the flight simulator to understand how flight test works. Main activity: Students review what they have learned about flight testing (previous lesson or reading assignment); students get directions for sim lesson (worksheet); students fly a simulated flight test profile, then discuss what they learned; students compare how aircraft are tested to the scientific method and see how flight testing follows basic experimental procedures.	MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-ETS1-2
16. Comparing reciprocating and jet engines	Opening: How do you think jet engines compare to reciprocating engines? Learning Target: I can compare jet engines to reciprocating engines by flying each of them. Main activity: Students review how reciprocating and jet engines work; students get directions for simulator lesson and worksheet; student crews fly simulators and note different performances of jet and reciprocating engines – especially fuel consumption vs. performance; students compare the different engine performances and discuss results.	MS-PS1-4 MS-PS2-1 MS-PS2-2 MS-PS2-4 MS-PS3-1 MS-PS3-3 MS-PS3-4 MS-PS3-5 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-PS2-1 HS-PS2-2 HS-PS3-1 HS-PS3-3 HS-PS3-4 HS-ESS3-2 HS-ETS1-2
17. Comparing turbine jet engines	Opening: How do you think different turbine engines fly? Learning Target: I can compare turbojet, turboprop, and turbofan engines by flying each of them. Materials: Flt sims, worksheets.	MS-PS1-4 MS-PS2-1 MS-PS2-2 MS-PS2-4 MS-PS3-1	HS-PS2-1 HS-PS2-2 HS-PS3-1 HS-PS3-3 HS-PS3-4

	Main activity: Students review the 3 types of turbine engines (turbojet, turboprop, and turbofan); students get directions for simulator lesson and worksheet; student crews fly simulators and note different performances of turbine engines; students compare the turbine engine performances and discuss results.	MS-PS3-3 MS-PS3-4 MS-PS3-5 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	HS-ESS3-2 HS-ETS1-2
18. Advanced Navigation – Flying Airways	Opening: What is the advantage of driving on a highway, compared to back roads? Learning Target: I can complete the flight test profile on the flight simulator to understand how airways work. Main activity: Students discuss how highways give a clear, direct route to a destination; students learn how airways are designed for the same purpose for airplanes in the sky; students learn about radio navigation aids (NAVAIDS) that define airways and how to use these NAVAIDS safely; students study airways near a departure airport and pick a route to a destination airport following the airways; students use radio navigation aids to fly the airway route; students discuss what they learned.	MS-PS4-1 MS-PS4-2 MS-PS4-3	HS-PS4-1 HS-PS4-2 HS-PS4-4 HS-PS4-5
19. Advanced Navigation – Using a Flight Management System (FMS)	Opening: How could we use GPS to fly the airway route in Aerospace Lesson 18? Learning Target: I can complete the flight test profile on the flight simulator to understand how a flight management system works. Main activity: Students discuss how GPS works; students learn how a flight management system (FMS) is a computer that incorporates GPS signals, along with NAVAIDS, to provide navigation guidance (plus it does many other tasks formerly done by navigators and flight engineers); students learn how way points can be set up, including along an airway; students also learn about navigation databases and how they are regulated and updated for safety; students open the flight simulator program and choose an airliner with a FMS; students practice programming way points into the flight management system, then they fly the route; students compare airway flying with FMS navigation and discuss what they learned.	MS-PS4-1 MS-PS4-2 MS-PS4-3	HS-PS4-1 HS-PS4-2 HS-PS4-4 HS-PS4-5

20. Advanced Navigation – Low Level Flying	Opening: Why do military aircraft sometimes fly very low to the ground, or low level? When would civilian aircraft want to fly low level? Learning Target: I can complete the flight test profile on the flight simulator to fly a low-level route. Main activity: Students discuss how reasons for low level flying (military – avoid detection; civilian – search and rescue); students plan a low level route around their departure airport; students discuss how they will navigate (dead reckoning and pilotage); students take off and fly the planned low level route; students discuss what they learned.	MS-PS4-2 MS-ESS2-2 MS-ESS3-3	HS-PS4-4 HS-ESS2-1 HS-ESS3-4