FLUIDS & EFFECTS OF TEMPERATURE

Unit 18, Dr. John P. Cise, Professor of Physics, Austin Com. College, Austin Tx., jpcise@austincc.edu & NYTimes , June 21, 2017 , by Zach Wichter

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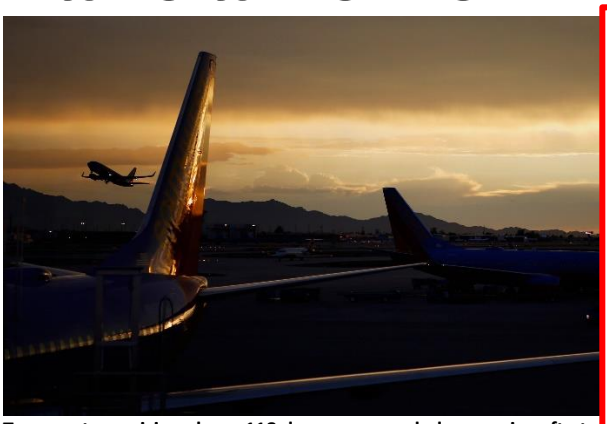
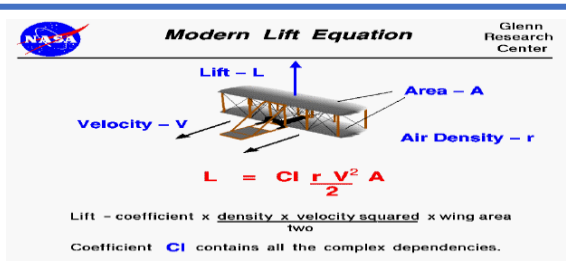
Too Hot to Fly? Climate Change May Take a Toll on Air Travel



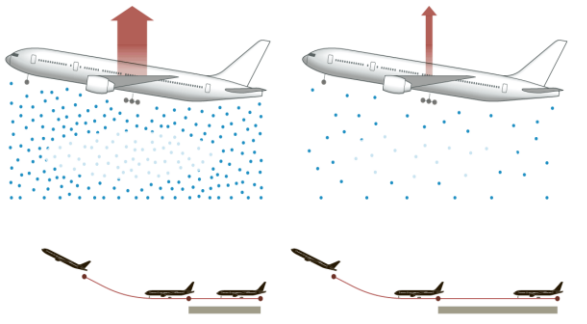
Temperatures rising above 118 degrees grounded some aircraft at the Phoenix Sky Harbor International Airport. The hot air was too thin to provide the lift they needed to take off successfully. In recent days, American Airlines has been forced to cancel more than 40 flights in Phoenix. The reason: **With daytime highs hovering around 120 degrees, it was simply too hot for some smaller jets to take off. Hotter air is thinner air, which makes it more difficult — and sometimes impossible — for planes to generate enough lift.** "Airplanes do not fly through a vacuum. The atmosphere is being modified by climate change." The problem in Phoenix primarily affected smaller jets operated by American's regional partner airlines. "When you get in **excess of 118 or higher, you're not able to take off or land,"** said Ross Feinstein, a spokesman for American Airlines, referring to the smaller aircraft. Bigger jets like Boeing 737s and Airbus A320s have higher operating thresholds (126 and 127 degrees, respectively), he said. All three of those maximum temperatures are specific to the Phoenix airport; **aircraft have different maximum operating temperatures depending on a variety of factors, including airport elevation.**

INTRODUCTION: From Bernoulli's concept (energy conservation for fluids) the lift on a airplane wing can be shown to be:
Lift = ½ ρ A v^2 C Where: ρ = density of air, affected by temperature. A = area of wings , v = speed of plane , C = coefficient of lift which depends on angle of attack of wing & other factors.



How Higher Temperatures Affect Flying

As temperatures increase, air density decreases, which reduces lift and makes it harder for airplanes to take off. To address this, airlines could reduce airplane weight (by loading fewer passengers and less fuel or cargo) or schedule departures for cooler periods of the day.



LOWER TEMPERATURES, HIGHER TEMPERATURES
More lift , Less lift DENSER AIR MOLECULES ,
SPARSER AIR MOLECULES Shorter takeoff runs ,Longer takeoff runs

Temperature - t - (^oF)	Density - ρ - (10^{-3} slugs/ft^3)	Specific Weight - γ - (10^{-2} lb/ft^3)
-40	2.939	9.456
-20	2.805	9.026
0	2.683	8.633
10	2.626	8.449
20	2.571	8.273
30	2.519	8.104
40	2.469	7.942
50	2.420	7.786
60	2.373	7.636
70	2.329	7.492
80	2.286	7.353
90	2.244	7.219
100	2.204	7.090
120	2.128	6.846

QUESTION: If a plane got adequate lift to take off at 50° F by going 130 mph, at what speed does the plane need to take off at when temperature is at 120° F? Use the table at left to find air density at various F temperatures.

ANSWER: $V_{AT\ 120\ DEGREES\ F}$ = 138.63 mph

COMMENT: Longer runway is needed to reach higher speed for adequate lift with low air density. Thanks Bernoulli!

Depending on their locations, airports may experience the effects differently. High-altitude airports like Denver have thinner air by nature, so lift is even more affected by higher temperatures. La Guardia Airport in New York could also be affected, even though it is at sea level. La Guardia has a short runway relative to other major commercial airports, and on particularly hot days that can be a problem: Planes might not have enough distance to achieve the speed and lift needed to get airborne.