Calculus Crash

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Introduction

As a quality consulting service for the airline industry and air traffic control, we are to investigate a possible FAA infraction. At 1:30pm, American Airlines flight 1003 was approaching Frada Heights at a heading of 171 at a speed of 405 knots being 44 nautical miles away. At the same time, US Airways 366 was 32 nautical miles from Frada Heights and was approaching it on a heading of 81 at a rate of 465 knots. Both planes were at the same altitude of 33,000 feet. The FAA regulation in question is whether or not these plane have more than five nautical miles separation between the two planes. Both planes travel over the city of Frada Heights, Iowa. Citizens of this town have observed that these two planes have had near misses.

The Department of Public Safety has asked to whether they did indeed break a FAA rule. If they did break the FAA rule, would air traffic controllers have enough time to take appropriate action, and is there a way of lowering one plane's elevation to cause a five nautical mile separation between the two.

Abstract

STEM Poster:Using Calculus in the Real World
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A small airline company was posed with the problem of investigating two flights to see if they met all public safety requirements. We acted as calculus consultants to solve the problem. We wanted to find out the speed the planes were moving towards each other and if they violated the rule of being any closer than 5 nautical miles apart. Also, we had to determine, when the planes were at their closest, how close were they and whether or not air traffic control had enough time to take appropriate action. Finally, we were asked if a change in altitude would avoid any dangerous flights. We used a series of different calculus and trigonometry equations to help us figure this problem.

Formulas

$a^2+b^2=c^2$

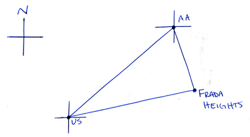
1.n.m.=6067.11549ft

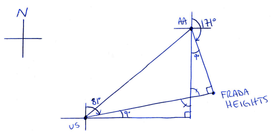
Step 1: Proving Right Triangle

In order to use Pythagoras Theorem, we must prove that the triangle that is formed by the two planes and the city is right. In order to do this, we must first draw the triangle formed by the two planes and the city.

Next, we draw another triangle from the points of the two planes. Using the 90° formed by the directions east and south, we form a right triangle.

Lastly, using the fact that opposite angles of bisected lines are congruent, we can confirm that the triangle is a right triangle.





Step 2: Finding the Equation

Next, is to find the equation. Because we have a right triangle, we can use the Pythagoras Theorem to find the equation to find our information. Given the data, we know the distance and rate in which these planes approach the city, we can plug in the values to get the following equation.

$a^2+b^2=c^2$

$a=44-465t$

$b=32-405t$

$(44-465t)^2+(32-405t)^2=c^2$

$\sqrt{(44-465t)^2+(32-405t)^2}=c$

Step 3: Finding Minimum

Using a graphing program, we graph the function, and find that the minimum is when t=6.21 minutes. At 1:36pm, the planes are at a distance of 4.7992 n.m. away from each other, thus they broke the FAA regulation.

t=time(min)	c=distance (n.m.)
3.45	23.846
4.14	17.847
4.83	12.018
5.52	6.8118
6.01	4.9422
6.21	4.7992
6.9	8.86

Step 4: Finding Alternative Altitude

Lastly, we need to calculate a distance so that these two planes are at a minimum of 5 n.m.

To do this, we form a right triangle, and knowing that the hypotenuse has to be at least 5 n.m, we solve for the other side. Once we do this, we convert to feet using the given conversion.

$a^2+b^2=c^2$
$a=4.7992$
$(4.7992)^2+b^2=c^2$
$c\geq5$
$c^2\geq25$
$(4.7992)^2+b^2\geq25$
$b^2\geq25-(23.032)$
$b\geq\sqrt{(1.968)}$
$b\geq1.4028$ n.m.
$1.4028*6067.11549=8510.9$ ft.
$33000-8510.9=24489.1$ feet

Conclusion

Based off our calculations, we have determined that the FAA rule was indeed broken. At 1:36pm, there was a distance between the two of 4.767742 n.m. To solve this issue, we calculated how much one plane must reduce altitude to keep the five mile separation, which was 9151.840ft.

After solving this experiment, we learned much about how much mathematics is used in the real world. Without doing these calculations or slightly having them calculated wrong, they could lead to dire consequences.