

National Aeronautics and Space Administration

Smart Skies™

**Distance-Rate-Time Mathematics
In Air Traffic Control**

Grades 6-7

Standards-Based Free!



Rebecca Green
NCTM Regional Conference - Houston, TX

20-Nov-2014

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NASA: With You When You Fly




Smart Skies™

2

NASA and the NextGen ATS





NASA plays a major role in NextGen research.

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Agenda



Introduction to Air Traffic Control
LineUp With Math Training <ul style="list-style-type: none"> Sector 33 air traffic control simulator Math strategies Practice with worksheets
How to access the classroom materials

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Challenges of Air Traffic Control



During the busiest travel times, about how many commercial planes are flying in the US?

About 5,000 planes!



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World's Largest D-R-T Problem

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24 Hours Of Flight
A 60-Second Animation



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Air Traffic Control 101




Ground Control (tower)
- from gate to runway

Local Control (tower)
- takeoff & landing

Terminal Radar Approach Control (TRACON)
- ascending & descending

En-Route Traffic Control (center)
- high cruising altitude



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Air Traffic Control 101




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Air Traffic Control 101



How do ATCs maintain safety & efficiency?


- Analyze** the situation.
- Detect** potential conflicts.
- Resolve** the problem.
- Communicate** the solution.

...and they use a little math along the way.


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Two Classroom Activity Sets




FlyBy Math: Gr. 5-8



Pre-algebra to Algebra

- Scenarios involving 2 planes
- Hands-on physical experiment
- Multiple representations (six math methods)
- Graphing simulator

LineUp With Math: Gr. 6-7



Pre-algebra

- Scenarios involving 2 to 5 planes
- Realistic air traffic control simulator
- Proportional reasoning

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www.smartskies.nasa.gov/lineup





LineUp With Math™

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Standards Based & Classroom Tested



- Aligned with both Common Core and State Standards:



- Distance = rate • time
- Proportional reasoning
- Problem solving
- Decision making

- Tested with 4,500 students nationwide

LineUp With Math™

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LineUp with Math

Math-Based Decisions in Air Traffic Control (ATC)



Workbooks



Web-based ATC simulator

- Act as an Air Traffic Controller
- Use a simulator and **math**
 - to change plane routes and speeds
 - to keep planes safely separated and on time

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6 Workbook Problem Sets

Introduction to ATC



Speed Changes



Route Changes



4-plane and 5-plane challenge problems are available (without workbooks).

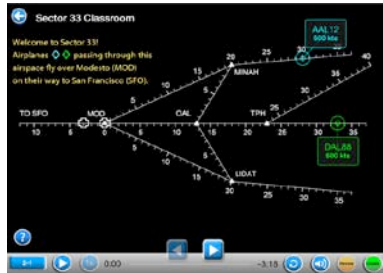
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Welcome to Sector 33

Introductory video for students available on student website: www.atcsim.nasa.gov

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Intro to the Simulator



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ATC Simulator Problem 3-8

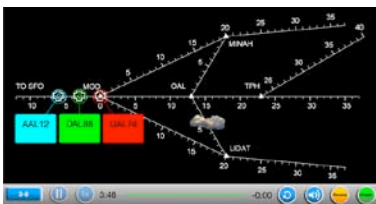
Line up 3 planes over MOD, 3 Nmi apart.



- Change route
- Change speed
- Match the target time.
- Requires math!

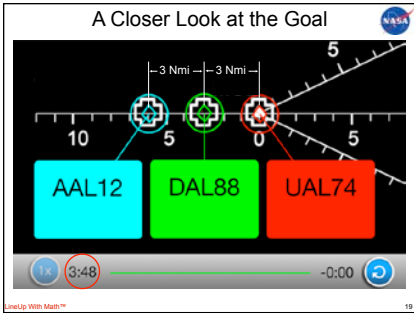
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The Goal Over MOD

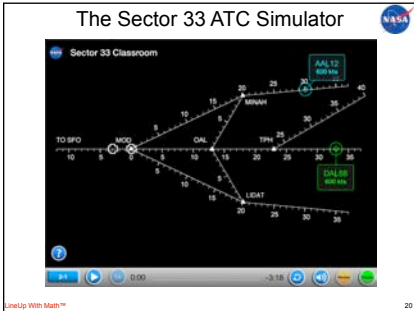


The planes must be spaced 3 Nmi apart over MOD. The last plane must arrive in 3 min and 48 sec.

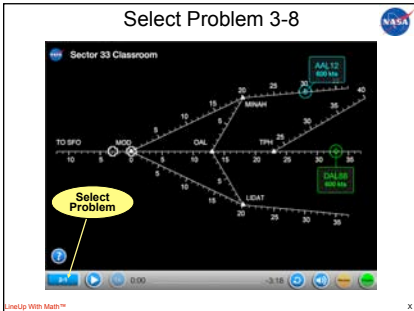
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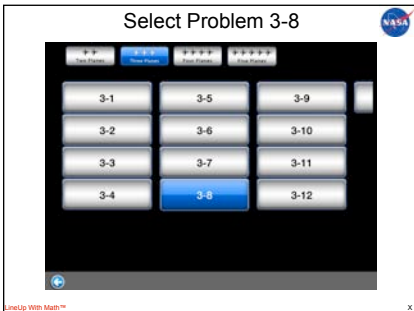
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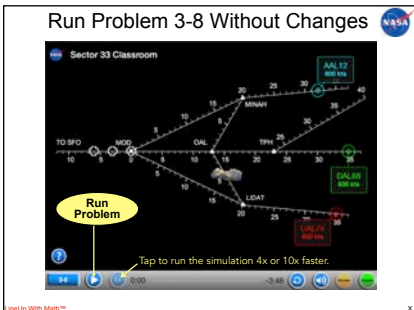
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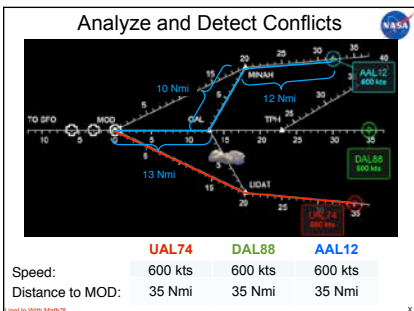
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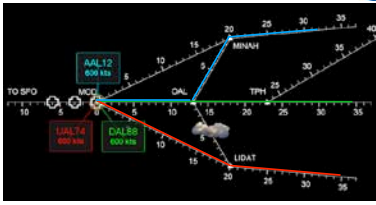


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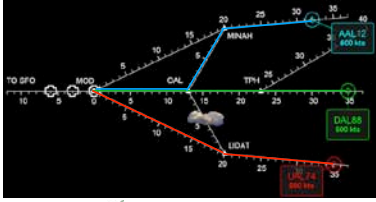
Analyze and Detect Conflicts



All 3 planes: Are the same distance, 35 Nmi, from MOD.
 Are flying at the same speed, 600 kts.
 Arrive over MOD at the same time!!!

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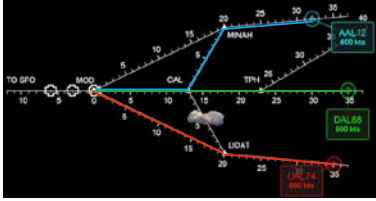
Ways to Resolve Conflicts



- ✓ Route Change(s)
- ✓ Speed Change(s)
- ⊗ Altitude Change(s)

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Try Using a Route Change

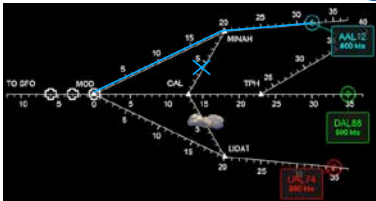


Can you change the route for:
 UAL74? DAL88? AAL12?

No No Yes

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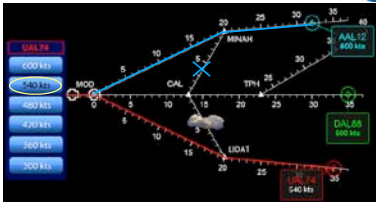
Verify the Route Change



Let's change the route for AAL12.
 What's its new flight distance to MOD? 32 Nmi

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Try Using a Speed Change



Let's reduce the speed of UAL74.
 Try 540 knots (smallest reduction).

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Communicate the Strategy

- "AAL12 cleared direct MINAH to MOD."
- "UAL74 reduce speed to 540 knots."

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Reset Problem 3-8

Reset

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Apply the Route & Speed Changes

Send AAL12 direct MINAH to MOD.

Slow UAL74 to 540 kts.

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Result of Route & Speed Changes

Note the spacing at the target time:
 3 Nmi between AAL12 & DAL88
 = 4 Nmi between DAL88 & UAL74

How can you keep UAL74 from falling so far behind?

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Review & Fine Tune the Solution

- Investigate the problem in Review mode.
- Pause at 1, 2, and 3 minutes.
- Note the plane spacing each minute.

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Review the Problem 3-8 Solution

Do not reset the problem.

Review

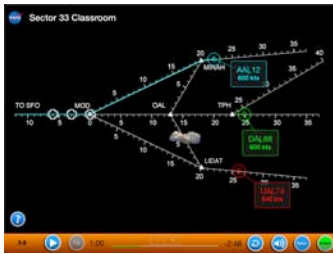
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Using Review Mode

Use the +/- to adjust the clock in one second increments.

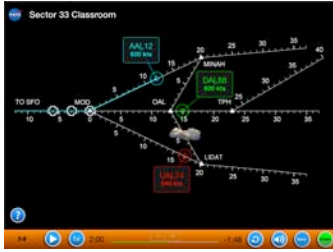
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At One Minute



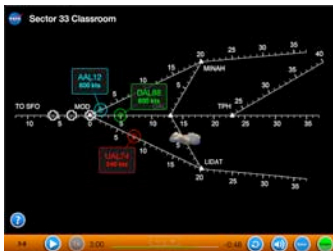
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At Two Minutes



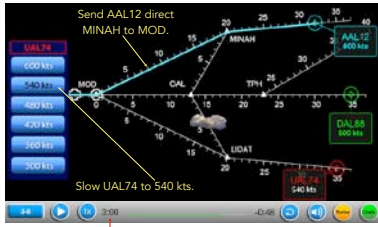
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At Three Minutes



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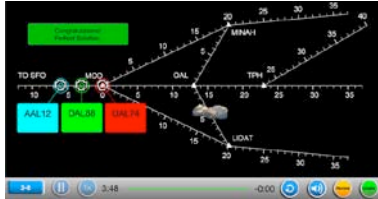
Fine Tune the Solution



After 3 minutes, speed up UAL74 to 600kts.

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Goal Achieved!



The planes are spaced 3 Nmi apart over MOD.
The last plane arrived in 3 min and 48 sec.

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Understanding Speed Change



■ We changed a plane's speed to achieve Ideal Spacing and meet the Target Time.

- How did we know which speed to select?
- Why is the speed menu in 60-knot increments?
600 kts, 540 kts, 480 kts ...



■ To explain, we begin with 2 walkers.

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The Math Behind Speed Changes

3 minutes 2 minutes 1 minute

Distance - steps

Gabby 10 steps/minute

Tonisha 9 steps/minute

$D = R \cdot T$

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Connect Knots & Steps Per Minute

- How do walker speeds (steps per minute) relate to plane speeds (nautical miles per hour)?
- Controllers make decisions in **minutes**, not hours. So controllers use speed in **miles per minute**.

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Minute by Minute

A plane's speed is **600** knots:
 In 1 hour, it flies 600 Nmiles.
 In 60 minutes, it flies 600 Nmiles.
 In 1 minute, it flies **10** Nmiles.

1 hr = 60 minutes

A plane's speed is **540** knots:
 In 1 hour, it flies 540 Nmiles.
 In 60 minutes, it flies 540 Nmiles.
 In 1 minute, it flies **9** Nmiles.

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Plane Spacing Each Minute

3 minutes 2 minutes 1 minute

Distance - Nmiles

DAL88 at 600 kts 10 Nmiles/minute

UAL74 at 540 kts 9 Nmiles/minute

UAL74 at 420 kts 7 Nmiles/minute

$D = R \cdot T$

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Reduce Speed in 60-Knot Increments

$D = R \cdot T$ $\Delta D = \Delta R \cdot T$

3 minutes 2 minutes 1 minute

Distance - Nmiles

DAL88 at 600 kts 10 Nmiles/minute

UAL74 at 540 kts 9 Nmiles/minute

UAL74 at 480 kts 8 Nmiles/minute

UAL74 at 420 kts 7 Nmiles/minute

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Solution Strategy

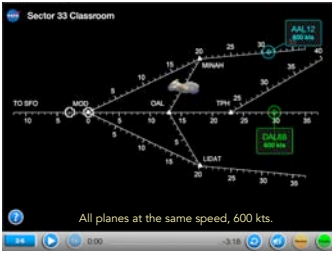
Determine:

- The order of plane arrival and spacing at MOD
- How much each plane must fall back
- If you can use a route change
- The degree of speed change and duration

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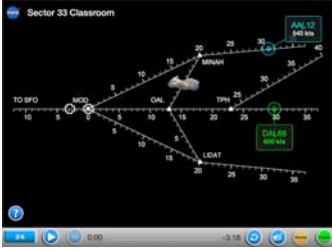
Analyze Problem 2-6



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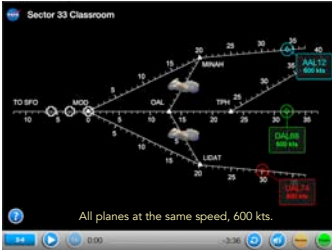
Solve Problem 2-6



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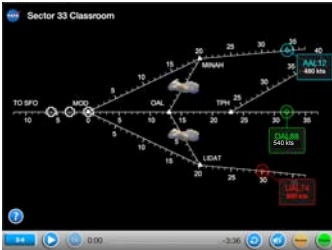
Analyze Problem 3-4



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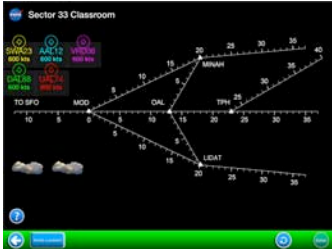
Solve Problem 3-4



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Create Your Own ATC Problems



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Classroom Implementation



Explore with the Simulator.



Do the math in a Workbook.



Meet the time challenge.



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LineUp With Math™ Materials
Free Online!

Educator Materials
Quick Start Guide
Educator Guide
Teacher Guide for each problem set with solutions
Answers and solutions to all simulator problems

Student Materials
Workbook for each problem set
Air Traffic Control simulator
Movies: 24-Hours of Flights, Welcome to Sector 33, and I'm an Air Traffic Controller

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Smart Skies home page
For Teachers

SMART SKIES
WHAT'S ON YOUR TABLE TODAY?

Distance Rate-Time Investigations
in Air Traffic Control (ATC)
Five Math Problems for Grades 5-8

LineUp With Math™
View a video
• Air traffic control simulator
• Pre-Algebra
• Operational reasoning
• Distance-rate-time

FlyBy Math™
View a video
• Hands-on experiments
• Pre-Algebra
• Modeling and graphing
• Distance-rate-time
• Algebra
• Graphing linear equations
• Distance-rate-time

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LineUp With Math home page
For teachers

LineUp With Math™

Math-Based Decisions
in Air Traffic Control (ATC)
Grades 7 - 8
 $D = R \cdot T$

Standards alignment

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Materials for Teacher Workshops
www.smartskies.nasa.gov/trainer

Teacher Workshops

Welcome to the Smart Skies™ workshop website!

FlyBy Math™
• Plan a 90-minute workshop

LineUp With Math™
• Plan a 90-minute workshop
• **NEW!** View a video workshop

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LineUp With Math Video Workshop
www.smartskies.nasa.gov/trainer/videos.html

Teacher Workshops

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Select a video segment from the online sequence

Expert Instruction

Watch anytime from anywhere!

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www.atcsim.nasa.gov

Simulator home page
For students & teachers

Air Traffic Control Simulator

Be an Air Traffic Controller!

Air Traffic Control Simulator
• Computer-based
• 2-5 airplane problems
• Extra! ATC Mobile App Games

Start here
• "24 Hours of Flight" video
• "Welcome to Sector 33" video
• "What's the Buzz?"

Learn more
• Simulator Quick Start Guide (MSK NA-139)
• Detailed Simulator Tutorial

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Interagency Partnership



- Partnership in education with the FAA
 - Classroom visits from air traffic controllers
 - Student visits to air traffic control facilities

www.faa.gov/education



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Sector 33 Mobile Game



www.nasa.gov/sector33

A real-world extension to
LineUp With Math:

- No pause button
- No review mode
- Student performance is scored
- Designed to further challenge students in a more realistic setting



for Apple & Android
mobile devices



LineUp With Math™

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Recent Recognition



The National Coalition for
Aviation and Space Education (NCASE)
awarded Smart Skies the:



2013 Dr. Mervin K. Strickler
Award for Aerospace
Education Leadership



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Contact Us



- **By email:** smartskies@mail.nasa.gov
- **On the web:** www.smartskies.nasa.gov

Send an email to smartskies@mail.nasa.gov if you would like:

- To be added to the Smart Skies email list
- To receive professional development for your dept/
district via distance learning

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Please complete the presentation feedback form.

Thank you from



What's on your radar screen?

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