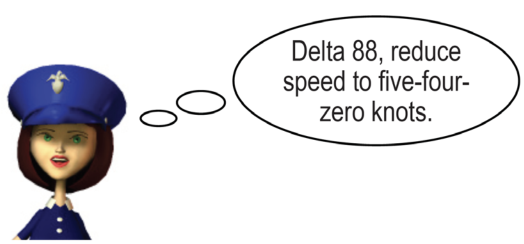
LineUp With Math™

Math-Based Decisions in Air Traffic Control

Student Workbook E

- **Resolving Air Traffic Conflicts by Changing Speed**
  - **2 planes, each at the same starting speed.**
  - **Simulator Problems 2-4, 2-5, 2-6, 2-7, 2-8.**

Simulator at:* *https://atcsim.nasa.gov/simulator/sim2/sector33.html



Investigator: ______________________

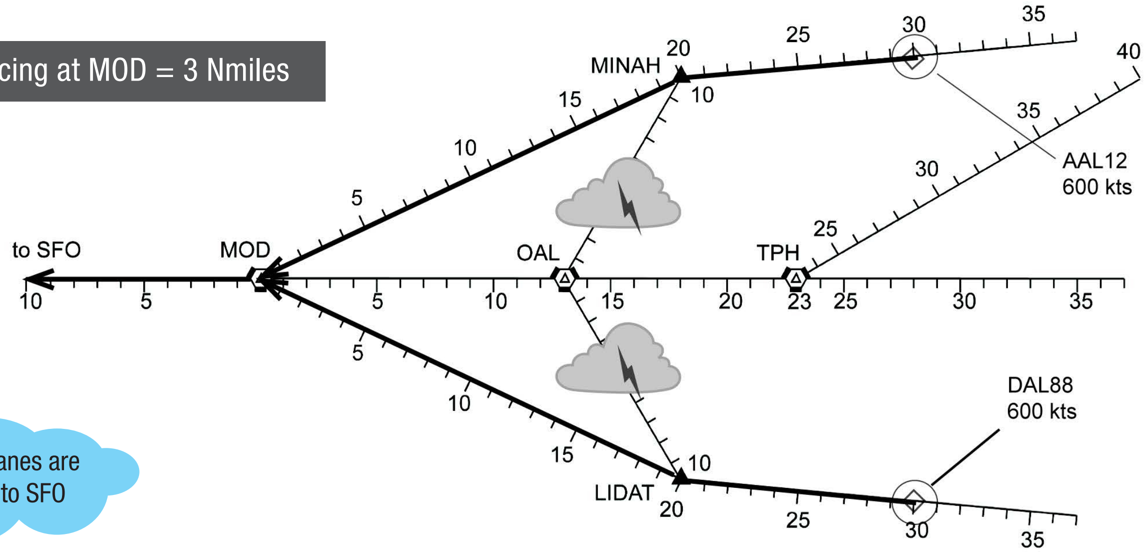
An Airspace Systems Program Product

EG-2006-08-111-ARC

Problem 2-4

Investigator: ____________________

Ideal Spacing at MOD = 3 Nmiles



Both planes are going to SFO

1 Speeds: ☐ Same ☐ Different

2 Headstart = ☐ Nmi = Separation at MOD

3 **Additional** Spacing Needed for Ideal Spacing (3 Nmiles) ☐ Nmi

How Much Time Before You Need Ideal Spacing?

4 At 600 knots, how many minutes will it take the planes to reach MOD? ☐ minutes

600 kts = 10 Nmi/Min

What Speed Change Will Solve the Problem?

You can't speed up a plane because they are at the maximum speed of 600 knots.

5 Instead reduce the speed of one plane by 60 knots. Choose one plane to slow to 540 knots: ☐

Remember: * A 60 knot difference in speed causes a 1 nautical mile difference in distance each minute.

6 At 540 knots, how many nautical miles less will this plane travel *each minute*? ☐ nautical miles *per minute*

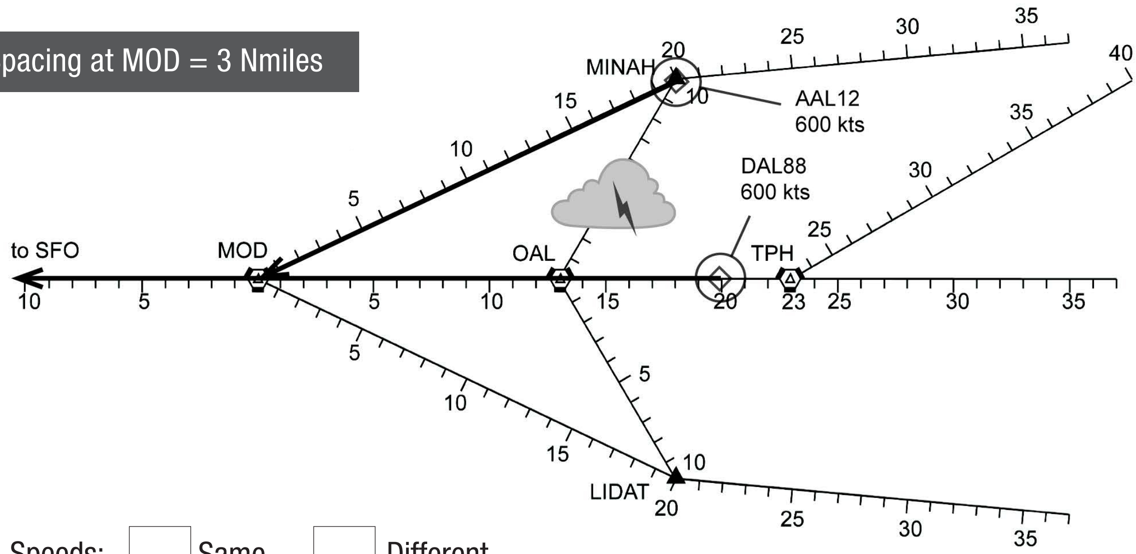
7 In 3 minutes, how much additional spacing will you gain due to the speed reduction? ☐ nautical miles

8 Does the 60-knot speed drop give Ideal Spacing at MOD? ☐ Yes ☐ No

End of Worksheet

Investigator: ____________________

Ideal Spacing at MOD = 3 Nmiles



1 Speds: ☐ Same ☐ Different

2 Spacing at MOD= ☐ Nmi

3 Additional Spacing Needed for 3 Nmiles= ☐ Nmi

* You must change speed to meet the Ideal Spacing.

4 At 600 knots, how many minutes will it take the planes to reach MOD? ☐ minutes

600 kts = 10 Nmi/Min

Remember * Controllers change speed in 60 knot steps.
* A 60 knot difference in speed causes a 1 nautical mile difference in distance each minute.

* First, slow AAL12 (or DAL88) by 60 knots, to 540 knots.

5 At MOD, how much spacing will you gain? ☐ nautical miles

6 Did the 60-knot speed drop give you Ideal Spacing at or before MOD? ☐ Yes ☐ No

Try a greater speed drop. Slow AAL12 by 60 + 60 = 120 knots, to 480 knots.

7 Now how much spacing will you gain at MOD? ☐ nautical miles

8 Did the 120-knot speed drop give you Ideal Spacing at MOD? ☐ Yes ☐ No

9 What could the controller do to achieve at least ideal spacing?

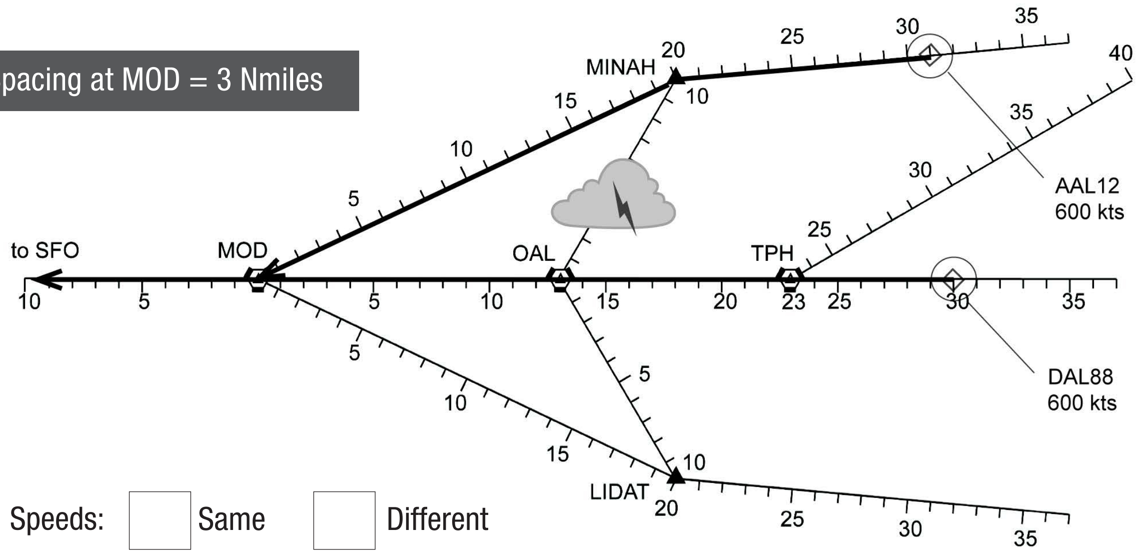
____

____

End of Worksheet

Investigator: ______________________

Ideal Spacing at MOD = 3 Nmiles



1 Speeds: ☐ Same ☐ Different

2 Spacing at MOD= ☐ Nmi

3 Additional Spacing Needed for 3 Nmiles= ☐ Nmi

4 At 600 knots, how many minutes will it take the **lead** plane to reach MOD? ☐ minutes

600 kts = 10 Nmi/Min

* Controllers usually slow down the trailing plane (*not* the leading plane).

5 Which plane would a controller slow down to 540 knots? ☐

* A 60 knot difference in speed causes a 1 nautical mile difference in distance each minute.

6 At this speed, how many nautical miles less will this plane travel each minute? ☐ nautical miles *per minute*

7 At MOD, how much additional spacing will be gained due to the speed reduction? ☐ nautical miles

8 What is the new spacing at MOD? ☐ nautical miles

9 Is the spacing ideal? ☐ Yes ☐ No

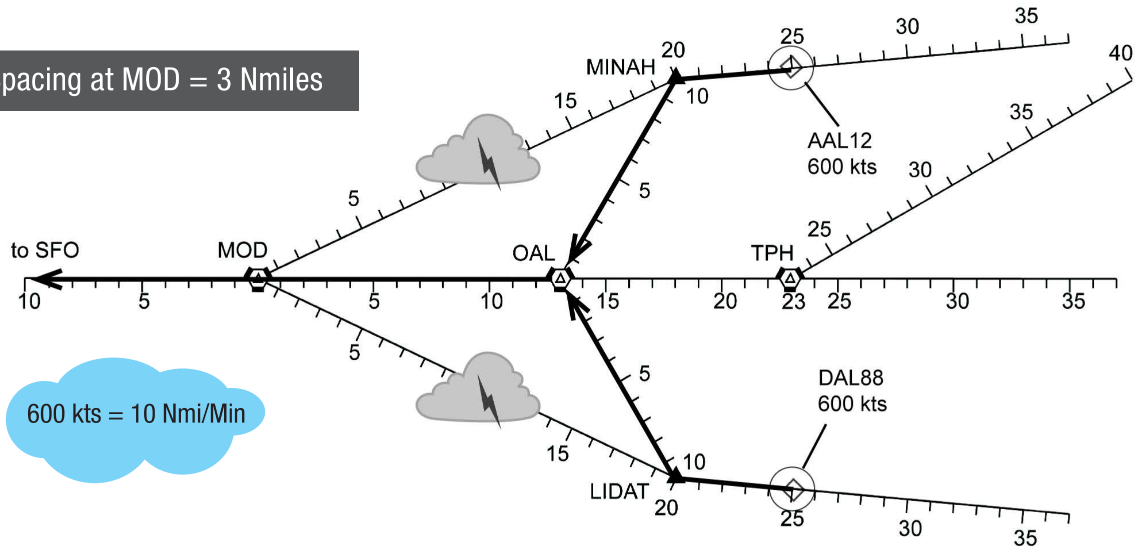
10 If no, after how many minutes will you speed the plane up to 600 knots to make the spacing ideal at MOD? ☐ minutes

End of Worksheet

Problem 2-7

Investigator: ______________________

Ideal Spacing at MOD = 3 Nmiles



Remember * Controllers change speed in 60 knot steps.
* A 60 knot difference in speed causes a 1 nautical mile difference in distance each minute.

* Analyze the problem at **OAL** (routes first meet). MUST meet or exceed **minimum** separation of 2 nautial miles.

1 Spacing at **OAL** = ☐ Nmi — Additional Spacing Needed for minimum separation of 2 Nmiles = ☐ Nmi

* Let's solve the problem by slowing one plane. Let's slow that plane to 540 knots.

2 Which plane will you slow? ☐

3 At **OAL**, how much additional spacing will be added due to the speed reduction? ☐ nautical miles

4 At 540 knots, will the planes have at least **minimum** separation of 2 nautial miles? ☐ No ☐ Yes — If no, what new speed will you use? ☐ knots

5 At the new speed, what will the separation be at OAL? ☐ nautical miles

6 At your final speed change, do you get at least **Minimum** Separation at OAL? ☐ Yes ☐ No

7 If Yes, when will you speed the plane up to 600 knots to get Ideal Spacing at **MOD**?

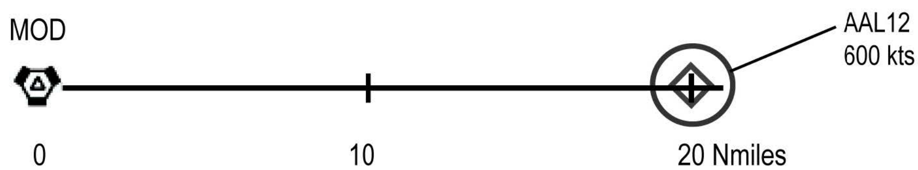
____

____

End of Worksheet

EXTENSION

- Now we will use a new method, the Percent Rule, to solve speed change problems. Here's an example.

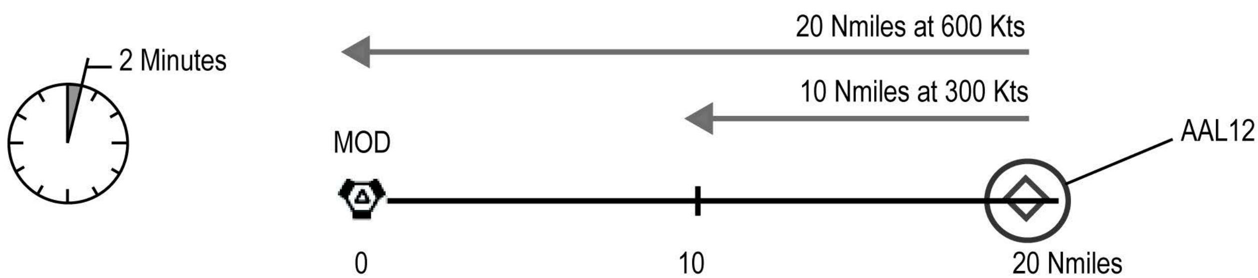


- At a speed of 600 knots, AAL12 travels 20 nautical miles to MOD in 2 minutes.

600 kts = 10 Nmi/Min

1 If we decrease the speed by 50% (that's 1/2 speed), then the new speed is ☐ knots

- At 300 knots (a 50% decrease in speed), AAL12 travels only 10 nautical miles (a 50% decrease) in 2 minutes.
- Here's a picture.

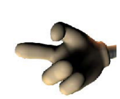


- So, in two minutes, we have:

Percent	Speed	Distance Traveled
100%	600 knots	20 nautical miles
50%	300 knots	10 nautical miles

- The 50% decrease in speed gives a 50% decrease in distance traveled in the same time. This is an example of the Percent Rule:

> For a given amount of time, when you decrease a plane's speed by a given percent, the plane's distance traveled is decreased by the same percent.



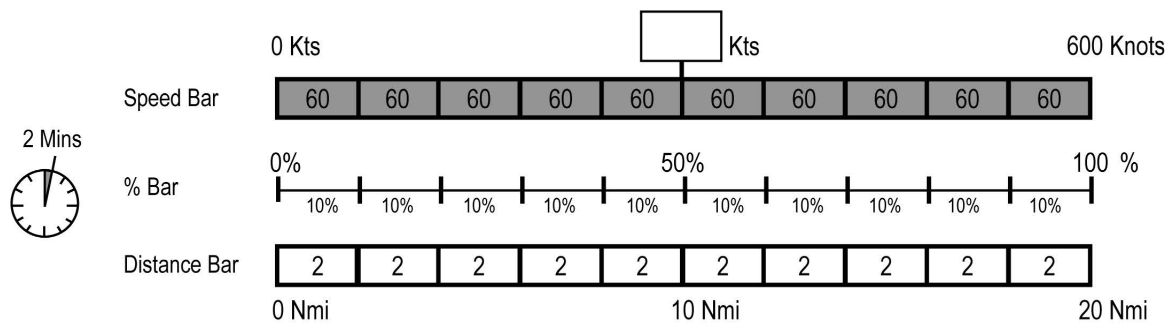
Continue to Next Page

Investigator: ______________

The % Method (continued)

% decrease in speed = % decrease in distance traveled

- Now we will use the Percent Rule to get additional spacing at MOD.
- In the picture below, the plane's maximum speed, 600 knots, is shown in 10% intervals (60 knots each) on the Speed Bar.
- The plane is 20 nautical miles from MOD.
  The distance to MOD is shown in 10% intervals (2 nautical miles each) on the Distance Bar.



2 Above the Speed Bar, in the empty box, fill in the plane speed that is 50% of 600 knots.

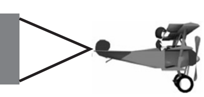
- Use this picture and the Percent Rule to answer Questions 3 through 5.

3 If we decrease speed by 60 knots, what is the % decrease in speed? ______ %

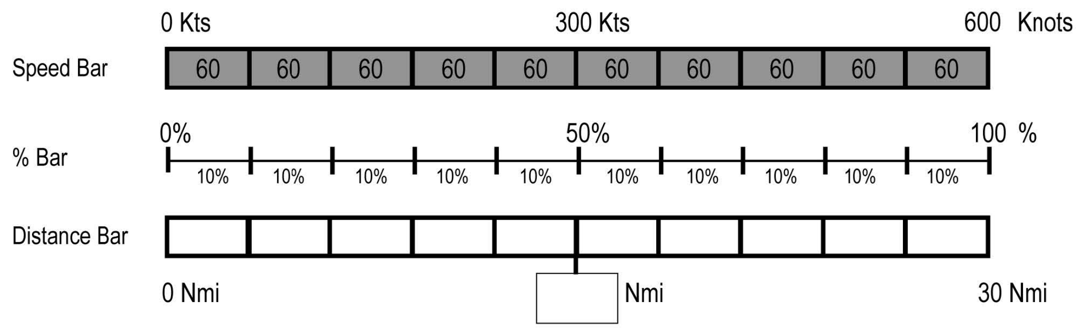
4 Using the Percent Rule, what is the % decrease in distance traveled in two minutes? ______ %

5 How many **fewer** nautical miles will the plane travel in two minutes? ______ nautical miles

End of Worksheet



- Now suppose the plane is **30 nautical miles** from MOD, traveling at 600 knots.



6 In the box below the Distance Bar, fill in the distance that is 50% of the **30 nautical miles** to MOD.

7 The distance to MOD is 30 nautical miles. For each 10% interval, fill each Distance Bar box with the number that is 10% of 30 nautical miles.

- Use this picture and the Percent Rule to answer Questions 8 through 12.

8 If we decrease speed by 120 knots, what is the percent decrease in speed? ______ %

9 Using the Percent Rule, what is the percent decrease in distance traveled in the same travel time? ______ %

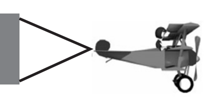
10 Using this percent, how many **fewer** nautical miles will the plane travel? ______ nautical miles

- Now the plane speed is **again** 600 knots.
  The plane travels **30 nautical miles** to MOD in a certain amount of time.
  But we don't need to know this time to answer this question.

11 To travel 9 **fewer** nautical miles (in this same time) by what percent would you reduce the plane speed? ______ %

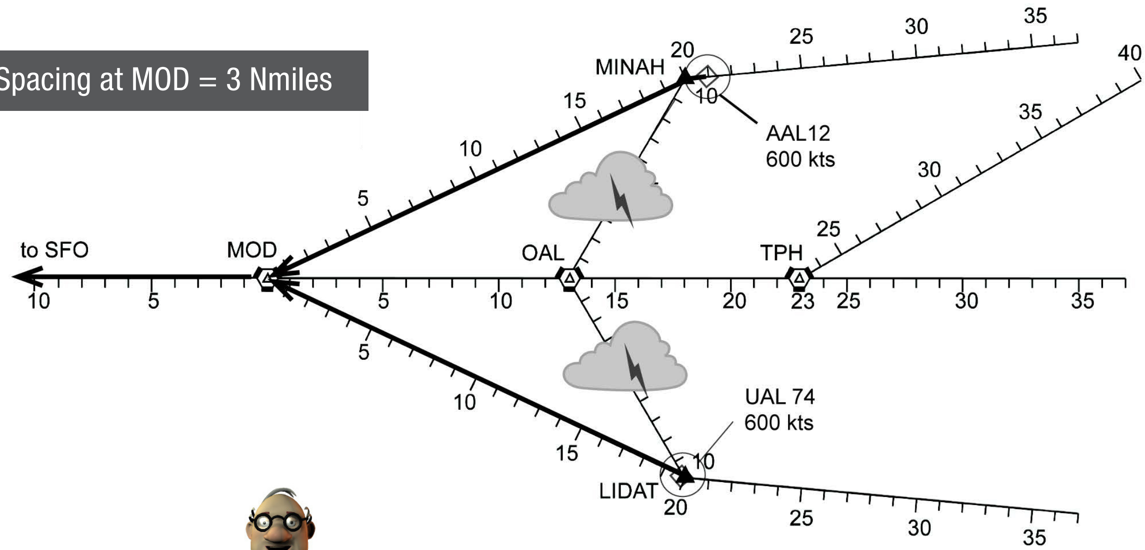
12 By how many knots would you reduce the plane speed? ______ knots

End of Worksheet



Investigator: ______________________

Ideal Spacing at MOD = 3 Nmiles



- Use the Percent Method to solve this problem.

1 Lead plane = [ ] Spacing at MOD = [ ] Nmi Additional Spacing Needed for 3 Nmiles = [ ] Nmi

* To achieve Ideal Spacing at MOD, decrease the speed of the trailing plane.

2 How many nautical miles does the *lead* plane travel to MOD? [ ] nautical miles

3 When the lead plane reaches MOD, the *trailing* plane has traveled [ ] the same [ ] a different distance.

4 What is the percent decrease in travel distance for the trailing plane?

$$\text{\% Decrease} = \frac{\text{Additional Spacing Needed}}{\text{Distance Traveld}} = \frac{\text{2 Nmiles}}{\text{20 Nmiles}} = \frac{1}{10} = \boxed{}\ \%$$

5 For the trailing plane to decrease its travel distance by 10%, decrease its speed by [ ] %

6 If you decrease the trailing plane's speed by 10%, what is it's new speed? [ ] knots

7 What is the new spacing at MOD? [ ] nautical miles

End of Worksheet