Investigation #6 – Driving Safety

1. a. How far can a car travelling at 60 mi/h go in 0.1 s?
   b. How far can a car travelling at 60 mi/h go in 0.5 s?
   c. How far can a car travelling at 60 mi/h go in 1.0 s?
   d. How far can a car travelling at 60 mi/h go in 2.0 s?
   e. How far can a car travelling at 60 mi/h go in 5.0 s?

For c, d, and e, use your scale model car (Car A) and map (Map A) to simulate these situations.

2. Travelling at 60 mi/h,

   (a) Estimate how far you will travel when you turn around to talk to a friend in the back seat. Assume it takes 2 s for this to happen.

   (b) Estimate how far you will travel when you search for a CD in the glove compartment. Assume it takes 1 s for this to happen.

   (c) Estimate how far you will travel when you turn to the side to see if the space next to you is clear for passing.

   (d) The low beams of your headlights will allow you to see about 160 feet in front of you at night. How long does it take your car to travel this distance?

   (e) Most drivers need about 1.5 s to react to a new situation. How far will your car travel in this time interval?

   (f) After the brakes are applied to a car traveling at 60 mi/h, the car needs about 227 feet to stop. Considering reaction time (about 1.5 s) and braking distance, how long a distance will it take to stop if you see a problem up ahead at night? Why does this show the dangers of driving at night?

   (g) What are the safety implications of these calculations?

For a - f, use your scale model car (Car A) and map (Map A)to simulate these situations.

3. When drunk, the reaction time of the average driver doubles from 1.5 s to 3.0 s.

   (a) How far will a drunk driver's car travel before it stops if it was traveling at 60 mi/hr? (Use the information provided in problem 2f.)

   (b) When talking on a cell phone, the reaction time of the average driver also doubles from 1.5 s to 3.0 s. How far will a "cell-phone-driver's" car travel before it stops if it was traveling at 60 mi/h?

   (c) What are the safety implications of these calculations?

For a and b, use the drunk driver scale model car (Car E) and map (Map A) to simulate these situations.

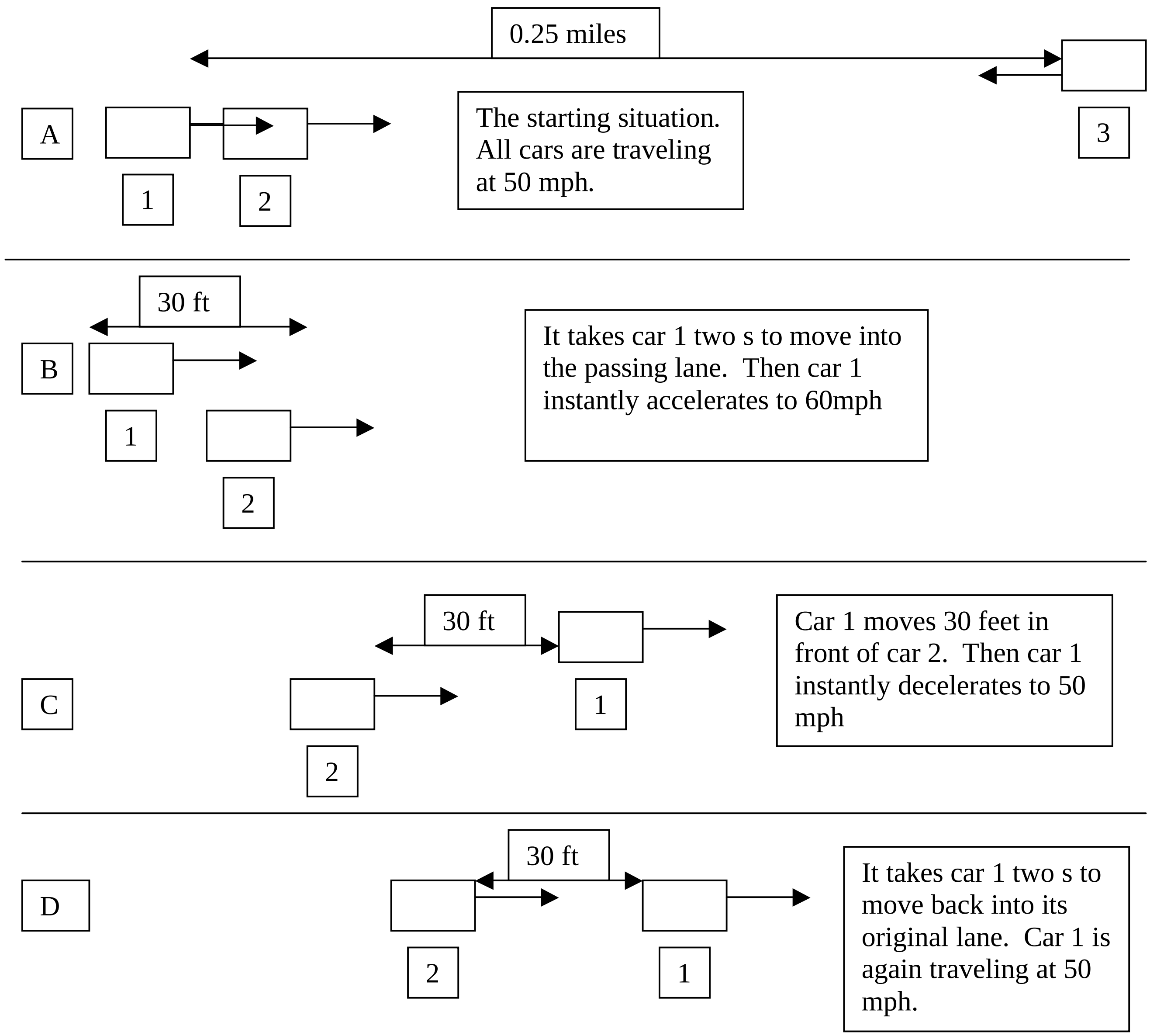
4. On a 2-lane road (one lane in each direction), you (car 1) decide to pass a car (car 2) in front of you that is traveling at 50 mi/h. You see another car (car 3) coming towards you from the other direction that is traveling at 50 mi/hr. When you are just behind car 2, you instantly accelerate to 60 mi/h and move into the other lane. You pass car 2 then move back into your original lane, and instantly decelerate back to 50 mph. Assume that it takes 2 s to travel into the passing lane and 2 s to move back into your original lane. Also assume that you will pass back into your lane when you are two complete car lengths in front of the car you are passing. Each car is 5 m long. The oncoming car is 0.25 miles away from car 1.

a. Will car 1 successfully pass car 2 without hitting the oncoming car 3?

b. If so, how many seconds later would your car and the oncoming car be at the same position on the road?

c. What lesson did you learn from this?

Use your scale model car B and map A to simulate these situations.


0.25 miles
A
1
2
3
The starting situation. All cars are traveling at 50 mph.
30 ft
B
1
2
It takes car 1 two s to move into the passing lane. Then car 1 instantly accelerates to 60mph
30 ft
C
1
2
Car 1 moves 30 feet in front of car 2. Then car 1 instantly decelerates to 50 mph
30 ft
D
2
1
It takes car 1 two s to move back into its original lane. Car 1 is again traveling at 50 mph.

5. Suppose you a traffic engineer working for the California Department of Transportation. Your job is to set the timing of traffic lights. You are also to only use metric units. How long should traffic lights be yellow for the following speeds: 45 km/hr, 65 km/hr, 85 km/hr, and 105 km/hr? Use the results of problem 5. Use car E and map A to simulate the effectiveness of your choice of yellow traffic light times.

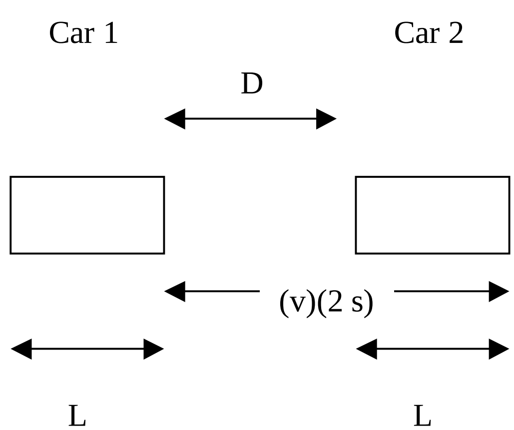
6. A general rule of thumb taught to drivers is to leave one car length of distance between cars for every 10 mph. Assume that a typical car length is 15 feet or 3 meters. Based on the results of problem 5, does this make sense? Why or why not? Consider 2 different cases.

a. You are traveling at 60 mph and suddenly the traffic in front of you slows to 50 mph.

b. You are traveling at 60 mph and suddenly the traffic in front of you slows to an abrupt stop. Why does this tend to lead to multi-car pile-ups?

Use your scale model car D and map A to simulate these situations.

7. Another way to judge appropriate spacing between cars when driving is to consider what is called "headway." Headway is defined as the elapsed time between the front of the lead vehicle passing a point on the roadway and the front of the following vehicle passing the same point. Most driving manuals recommend a headway of at least 2 s. How does a headway of 2-s compare to the rule of thumb that you should leave 1 car length between the front of your car and the back of the car in front of you for every 10-mph of speed?
Hint 1: Assume that each car length is 14.7 ft long. Recall that 10mph = 14.7 ft/s.
Hint 2: Assume two cars are moving at the same constant speed, one behind the other. Call the speed v. At time t = 0 the front of the lead vehicle passes a given point on the highway. Two seconds later the front of the second vehicle passes that same point. The total distance between the front of the two vehicles is therefore (v)(2 s).
Use your scale model car D and map A to simulate these situations.



8. You are driving at night to a friend's house. You make a sharp right hand turn onto another street and suddenly, 75 feet in front of you, you see someone crossing the street. Based on the results of problem 5, what is the maximum speed you could be traveling at and not hit the person. How fast should you be driving when making a turn onto a street at night?
Use your scale model car D and map A to simulate this situation.

9. Headlights illuminate the road up to 160 feet in front of you. If you are on a road with stop signs, what is the fastest speed you can drive and still stop safely at night?
Use your scale model car D and map A to simulate this situation.

10. A fire engine is traveling at 25 m/s towards the Doppler bus station on its way to a fire. At its closest approach it passes right next to the station. Starting at 500 m before the station, it sends out a short blast of sound every 100 m. It stops sending these messages when it is 500 m past the station. Sound travels at 330 m/s. If you are standing at the Doppler bus station, determine the time interval between successive blasts of sound. Calculate and compare how the time intervals change when the fire engine is approaching you versus when it is moving away from you.

10A. A fire engine is traveling at 25 m/s on its way to a fire. At its closest approach it passes 100m from a bus station. Starting at 400 m before the station, it sends out a very short blast of sound every 100 m. It stops sending these messages when it is 400 m past the station. Sound travels at 330 m/s. If you are standing at the bus station, determine the time interval between successive blasts of sound. Calculate and compare (using a table and a chart) how the time intervals change when the fire engine is approaching you versus when it is moving away from you.

11. Jack and Jill each drive their vehicles 10,000 miles per year. Jack's vehicle has a fuel economy of 10 miles per gallon, Jill's 30 miles per gallon.
    a. How much fuel does each of them use in a year?
    b. How much fuel does the Jack and Jill household use in a year?
    c. How far do they travel in a year?
    d. What is their average household fuel economy? Is it the average of Jack's fuel economy and Jill's fuel economy?
    e. What would their average household fuel economy be if Jill's vehicle got 100 miles per gallon?
    f. What would their average household fuel economy be if Jill's vehicle got 1000 miles per gallon?
    g. What would their average household fuel economy be if Jill's vehicle got 10,000 miles per gallon?
    h. What would their average household fuel economy be if Jack's vehicle got 30 miles per gallon, the same as Jill's original vehicle?
    i. If you were in charge of making policy to reduce fuel consumption, what would you do?

12. Consider the following distribution of dots on the line below. Let's call the dots "galaxies" and let's call the line "the universe." Suppose that adjacent galaxies are all located a distance of L apart from each other in the universe. At a time T later, the universe has expanded a factor of two so that now all of the adjacent galaxies are a distance of 2L apart.

a. Suppose you are living in galaxy A. How fast does it appear that galaxies B, C, and D are receding from you?

b. Is there a correlation between the distance the galaxy is located from you and the speed with which it is receding from you. What is that relationship?

c. Do people in each galaxy see the same thing happening?