Name:________________________________ Accident Reconstruction Lab

Scenario:

- Vehicle: 2011 Dodge Charger
- Brakes when pedestrian is visible leaving skid marks 260 ft long
- Impacts the pedestrian 70 ft before coming to a stop
- 75 feet from where the pedestrian could be seen (sight threshold) and beginning of the skid
- Friction factor of .6
- Speed limit is 55 mph (24.59 meters/sec)

1) How fast was the vehicle going at the start of the skid?

2) What was the driver's reaction time?

3) What is the vehicle's speed at time of impact?

4) Would the driver have struck the pedestrian if they were going the posted speed limit? If so, how fast would they have been going?

Accident reconstruction lab:
Officer... I didn't see them in time! I swear!
A lab modified from Syracuse University

Introduction

There has been an accident involving a vehicle and a pedestrian. The pedestrian was struck by the vehicle after it had skidded through a crosswalk. You have been hired as an expert accident reconstructionists. You will have a few questions to answer in your investigation:

1) How fast was the driver going when they entered their skid
2) How long did it take the drive to react to seeing the pedestrian?
    a) Were they impaired, distracted, or did they respond in a reasonable amount of time given how fast they were going.

Background

Vehicular accident reconstruction is the scientific process of investigating, analyzing, and drawing conclusions about the causes and events during a vehicle collision. Reconstructionists are employed to conduct in-depth collision analysis and reconstruction to identify the collision causation and contributing factors in different types of collisions, including the role of the driver(s), vehicle(s), roadway and the environment. The laws of physics and engineering principles such as the conservation of linear momentum, work-energy methods, and kinematics are the basis for these analyses and may make use of software to calculate useful quantities.

The accident reconstruction provides rigorous analysis that an expert witnesses can present at trial. Accident reconstructions are done in cases involving fatalities, and often when personal injury is involved. Results from accident reconstructions are also useful in developing recommendations for making roads and highways safer, as well as improving safety aspects of motor vehicle designs. These reconstructions are often conducted by forensic engineers, specialized units in law enforcement agencies, or private consultants.

Scene inspections and data recovery involves visiting the scene of the accident and investigating all of the vehicles involved in the collision. Investigations involve collecting evidence such as scene photographs, video of the collision, measurements of the scene, eyewitness testimony, and legal depositions. Additional factors include steering angles, braking, use of lights, turn signals, speed, acceleration, engine rpm, cruise control, and anti-lock brakes. Witnesses are interviewed during accident reconstruction, and physical evidence such as tire marks are examined. The length of a skid mark can often allow calculation of the original speed of a vehicle for example. Vehicle speeds are frequently underestimated by a driver, so an independent estimate of speed is often essential in accidents. Inspection of the road surface is also vital, especially when traction has been lost due to black ice, diesel fuel contamination, or obstacles such as road debris. Data from an event data recorder also provides valuable information such as speed of the vehicle a few seconds for a collision.[3]

Vehicular accident reconstruction analysis includes processing data collecting, evaluating possible hypotheses, creating models, recreating accidents, testing, and utilizing software simulations. Like many other technical activities, accident reconstruction has been revolutionized by the use of powerful, inexpensive computers and specialty software. Various types of accident reconstruction software are used to recreate crash and crime scenes and to perform other useful tasks involved in reconstructing collisions. Accident reconstruction software is regularly used by law enforcement personnel and consultants to analyze a collision and to demonstrate what occurred in an accident. Examples of types of software used by accident reconstructionists are CAD (computer aided design) programs, vehicle specification databases, momentum and energy analysis programs, collision simulators, and photogrammetry software.

After the analysis is completed, forensic engineers compile report findings, diagrams, and animations to form their expert testimony and conclusions relating to the accident. Forensic animation typically depicts all or part of an accident sequence in a video format so that non-technical parties, such as juries, can easily understand the expert's opinions regarding that event. To be physically realistic, an animation needs to be created by someone with a knowledge of physics, dynamics and engineering. When animations are used in a courtroom setting, they should be carefully scrutinized. Animation software can be easily misused, because motions which are not physically possible can be displayed. A reliable animation must be based on physical evidence and calculations which embody the laws of physics, and the animation should only be used to demonstrate in a visual fashion the underlying calculations made by the expert analyzing the case.[4]

References:

- http://en.wikipedia.org/wiki/Vehicular_accident_reconstruction
- https://sites.google.com/a/westwood.k12.ma.us/physicsastronomylessonplans/auto-accident-reconstruction-investigation

The Scenario

A car approaches a curve that leads to a straightaway. The road is dry, the posted speed limit is 35 mph (15.65 meters per second). As the car comes around the curve, the driver notices a pedestrian in a crosswalk up ahead. The driver firmly applies the brake, locking up the car's wheels and then leaving skid marks. Nevertheless, the car strikes and injures the pedestrian in the crosswalk and then comes to a rest a short distance later.

The driver swears that he is sober and was not speeding. He says he was observing the posted speed limit and that there is no way he could have stopped in time to avoid the collision.

If the driver is found to have been speeding he will face criminal charges. If his reaction time is found to be sufficiently long enough to indicate that he was driving under the influence of alcohol he will face additional charges. As an investigator, it is your job to answer these questions. To do so, you will need to use you knowledge of accident reconstruction. Use sound scientific techniques, as your findings will determine if charges will be brought against the driver.

THINGS TO ASSUME:

- The model has a scale of 1:70. That is, 1 cm on the model represents 70 cm in real life
- The driver does not turn to avoid the pedestrian.
- The car does not have anti-lock brakes.
- All four wheels of the car lock up and skid.
- The driver does not gradually apply the brakes—the instant he touches the brake pedal the wheels lock up and leave skid marks.
- The pedestrian is in the middle of the crosswalk before the car comes around the turn, and the pedestrian does not move prior to the collision.

Procedure

Crime Scene Photo 1

Crime Scene Photo 2

How fast were they going?

In order to determine how fast the car was going as they began to skid you will need to know a few things.

a) How long was the skid
b) What was the coefficient of friction
c) What is the equation that relates skid length to speed

The first thing you will determine by using the scale model of the accident scene, measuring it and scaling it up to get the real life distance. The coefficient of friction you will determine by using our model cars and dragging them using the spring scales. Record your data in the appropriate data tables.

a) Determining the length of the skid (use the photos for virtual lab)

1) Measure the length of the skid in centimeters. Record the distance on the data table
2) Convert the scale distance to actual distance. The model used a 1:70 scale

b) Determining the coefficient of friction (data provided for virtual lab)

The coefficient of friction is simply the force of friction divided by the normal force (the force due to gravity). Mathematically, it can be expressed as

$f = F_{Kfriction} / F_{normal}$

1) Measure the force of friction using a spring scale. Do this by dragging a model car using the spring scale at a constant velocity of about 30 cm/s. Record the force as displayed on the spring scale. This is your force due to kinetic friction. $F_{Kfriction}$
    a) You may notice that there is a large spike when you first try to get the car sliding. This is because the coefficient of friction for static objects is much greater than the coefficient of friction for kinetic objects (objects in motion). You have probably experienced this first hand if you have ever tried to slide large furniture around. It is more difficult to get it moving, but once it is moving it is a lot easier to keep it sliding. This is why it is important to make sure you are pulling the car at a constant velocity.
2) Measure the force of gravity on the model car (F_{normal}) by suspending it from the spring scale and recording the force displayed on it. This is your F_{normal}.
3) Use these 2 values to calculate the coefficient of friction (f).

c) Determine the speed at the beginning of the skid

Now that you know how long the skid was (d), and the coefficient of friction (f), determine the speed at which the car was going when it began to skid using the following equation

$$V = \sqrt{(2\ g\ f\ d)}$$

Where v = velocity, g is gravity (9.81 m/s^2), f is is your coefficient of friction and d is your distance in meters

How long did it take the driver to react?

Now that you know how fast the driver was travelling, you will be able to determine what their reaction time was to seeing the pedestrian. This is important for a few reasons. If the drive took an excessive amount of time to respond to seeing the pedestrian, they may have been distracted while driving or under the influence of drugs or alcohol while driving. The equation that relates speed and time together is:

Velocity = distance / time

In this scenario, you have previously determined the velocity and you will measure the distance between where the driver would have seen the pedestrian (the sight threshold) and where they entered the skid. You can use that distance to determine how long it took the driver to apply the brakes by rearranging the equation with a little algebra:

Time = distance / velocity.

In this part of the lab you will need to determine:

a) How long did it take the driver to apply the brakes
b) How long does it take an undistracted driver to apply the brakes
c) How long does it take for a distracted drive to apply the brakes

a) How long did it take the driver to apply the brakes

1) Measure the distance between the sight threshold and the beginning of the skid on the model in cm. Record in the data table
2) Convert the scale distance to real life distance in meters.

3) Determine the drivers reaction time using t=d/v

b) How long does it take an undistracted driver to apply the brakes?

1) Go to https://faculty.washington.edu/chudler/java/redgreen.html and complete the exercise 5x to get an average, undistracted reaction time. Record the data in the data table

c) How long does it take for a distracted driver to apply the brakes

1) Repeat the procedure in Part B above, only this time have the driver perform the following tasks and record their reaction time:
   a) Listening to music: The driver should find their favorite pump up song to listen too and they must sing along to it like nobody's around, like they do when they are alone in the car.
   b) Talking on the phone: The driver should find someone that they can talk to on the phone. They must try to have an authentic conversation with the person. Don't know what to talk about? Ask them about their day. Tell them something that you appreciate about them that you may not have told them. Ask them about the time when they were the happiest. Or you can talk about the weather.
   c) Texting: The driver should have a text conversation with someone. Pick someone that will reply, or atleast keep you thinking they are going too with the suspense of the three dots appearing. ALSO, make sure you're trying to be covert about the texting, hold it below 'the dashboard' so cops have a harder time catching you texting while driving.

Data and Calculations

a) **Determining the length of the skid**

1) Scale length of the skid in cm:______
2) Actual length of skid in m (show your work below):________

b) **Determining the coefficient of friction**

1) $F_{Kfriction}$: _300 N_____

2) F_{normal}: _410 N____

3) f; Coefficient of friction (show work below): ________

c) **Determine the speed at the beginning of the skid**

1) Show your work for calculating the speed at the beginning of the skid using $V = \sqrt{(2\ g\ f\ d)}$, Where v = velocity and g is gravity (9.81 m/s^2). Make sure to include units and to circle your final answer

How long did it take the driver to react?

a) How long did it take the driver to apply the brakes?

1) Distance between sight threshold and beginning of the skid on scale in cm: __________

2) Actual distance in real life in meters (show work below): __________

3) Calculate the driver's reaction time using t=d/v in seconds: __________

b) How long does it take an undistracted driver to apply the brakes?

Average reaction time: ________s

c) Distracted driver reaction time:

Listening to music trial: ________s

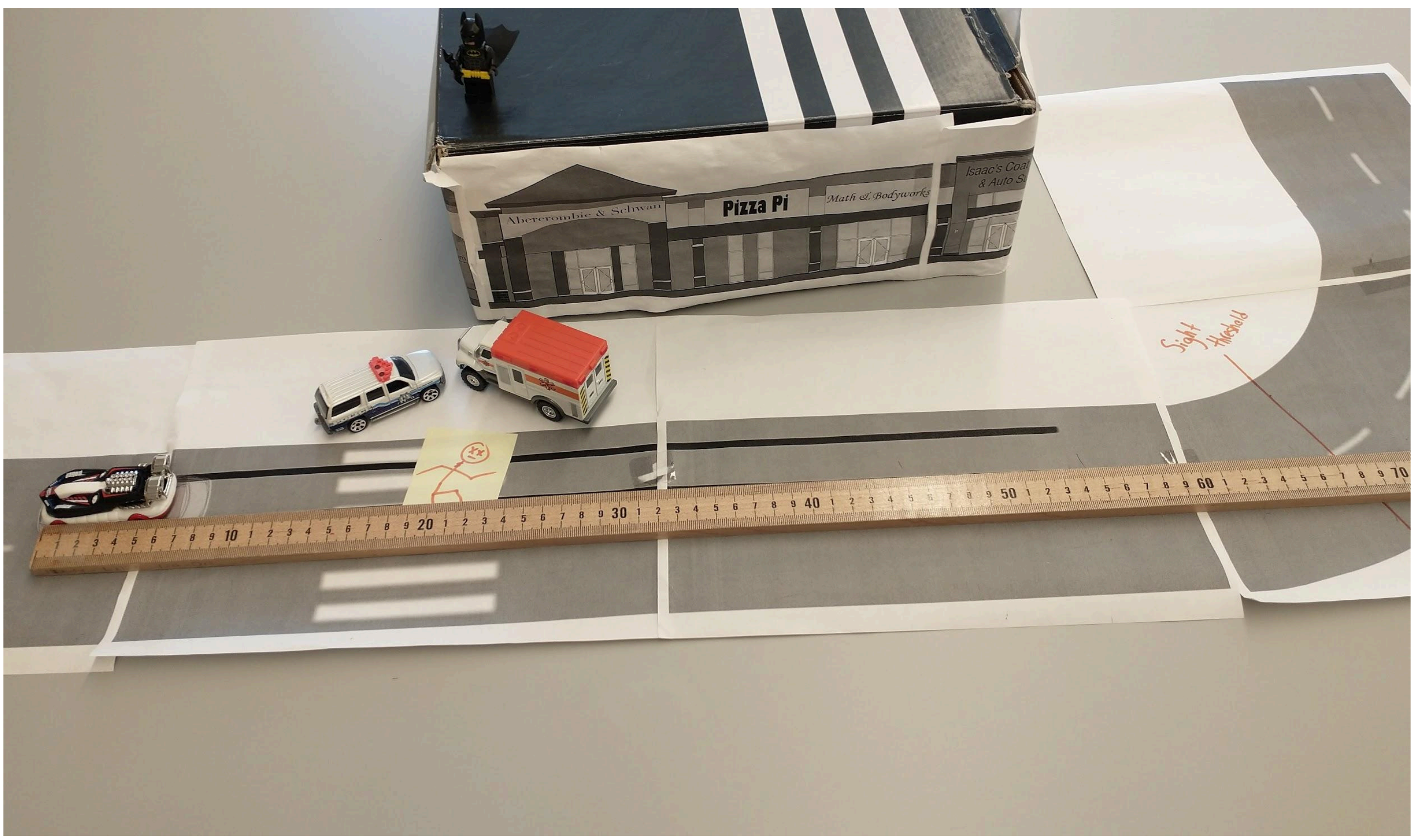
Talking on the phone trial: ________s

Texting trial: ________s

The Accident Report

The write up for this lab will be a police investigator's report of the accident. This should be a detailed explanation of your procedure and calculations, essentially talking your way through all of the steps, and should conclude by stating definitively the answers to the questions the investigation sets out to answer—was the driver speeding, and was the driver's reaction time negligently long? Make specific reference to your data and calculations when answering these questions. Each group of investigators must write a single report. Google Docs is highly recommended as a tool for writing collaborative papers, but it is not required.


Sight threshold


Abercrombie & Schwan
Pizza Pi
Math & Bodyworks
Sight threshold