**Case Number 169100 The Case of the Hit and Run Vehicle**

A hit and run accident involving an automobile and a bicycle recently occurred in your jurisdiction. At the scene several tire fragments and plastic fragments were recovered. A suspect was apprehended shortly after the accident. His automobile as well as his girlfriend’s and mother’s vehicle were examined for trace evidence and compared to materials found at the scene. Your task is to compare the densities of the rubber fragments and plastic fragments to the materials found at the scene by density comparison. The purpose of that is to see if the densities of any of the objects match. A match in the densities of one or more objects increase the likelihood that the suspect’s automobile was at the scene but of course is not definitive.

Plastics and rubbers from various sources such as windowpanes, tires, automobile headlights, bottles, hoses, and any number of plastic objects, all have slightly different densities. This makes it possible, in some cases, to help place a suspect at the scene of the crime. The density of the plastic or the rubber may by only slightly different but careful analysis will make these differences apparent. Table 1 gives the density of several types of materials.

**SAFETY**

This forensic investigation will require you to work with broken plastics which could be sharp. The plastic pieces should be handled with forceps only. Ethanol and sodium chloride will be used in this experiment as well. Prior to lab look up the material safety data sheets for these two chemicals and report them in your pre-lab.

**Pre-lab:** Include the experiment name, the purpose of the experiment, the major experimental steps used to achieve this purpose and a summary of the safety precautions for dealing with ethanol and sodium chloride.

Table 1 Densities of Various Common Materials (g/cm3)

|  |  |  |  |
| --- | --- | --- | --- |
| **Material** | **Density** | **Material** | **Density** |
| Amber | 1.06 – 1.11 | Mica | 2.6 – 3.2 |
| Celluloid | 1.4 | Quartz | 2.65 |
| Bone | 1.7 – 2.0 | Beryl | 2.69 – 2.70 |
| Porcelain | 2.3 – 2.5 | Glass, flint | 2.9 – 5.0 |
| Glass, window | 2.47 – 2.56 | Diamond | 3.01 – 3.52 |
| Glass, headlight | 2.47 – 2.63 | Aluminum | 2.702 |
| Brass | 8.4 – 8.7 | Lead | 11.34 |

**Exploration**

Before you request the actual evidence, you need to become proficient at measuring the density of other regular and irregularly shaped objects.

**Part 1: DENSITIES OF REGULARLY SHAPED SOLIDS**

In this part of the experiment, the volumes of regularly shaped objects are calculated from measurements of their dimensions. In each case the appropriate formula is applied:

rectangular solid: V = length x width x height

cube: V = (side)3

cylinder: V = π x (radius)3 x height

sphere: V = 4/3 x π x (radius)3

triangular solid: V = ½ x base x height x width

The mass is found by direct measurement with a balance and the density calculated:

density = mass/volume

**PROCEDURE**

1. Start with a rectangular solid. Weigh it and record the mass on a data table in your notebook.

2. Measure the length, width and height with a micrometer and record in a data table in your notebook.

3. Calculate the volume of the rectangular solid and record the value on the data table:

volume = length x height x width

4. Calculate the density of the rectangular solid and record the value on the data table:

density = mass/volume

5. Choose another regularly shaped solid and determine its density.

6. Repeat for a third object.

7. Based upon the calculated densities and table 1, determine the likely material each object is. What limitations do you have in assigning object material with certainty?

**Part 2: The Density Of Irregularly Shaped Solids**

You are now ready to measure the density of several irregularly shaped objects. To do so you will use a method called water displacement.

Water displacement is a simple way to measure the volume of a solid object. It is especially useful with irregularly shaped objects. Water is poured into a graduated cylinder or measuring cup and its volume read and recorded. The solid is completely submerged in the water and the volume of water plus object read and recorded. The volume of the object is found by subtracting the volume of the water from the volume of the water plus object. The mass is found by direct measurement with a balance and the density of the object is calculated using the formula:

density = mass/volume

As you are completing this part of the experiment, keep in mind the information the instructor has presented about significant figures.

**PROCEDURE**

1. A variety of small objects are available for check-out from the instructor. When you get your bag, record the evidence number and describe, in your notebook, the objects that you have.

2. For each object, weigh the object and record the mass on the data table.

3. Fill a graduated cylinder partially full of water and record the volume. Use the proper number of significant figures.

4. Add a solid object to the graduated cylinder. If it sinks but is not completely covered with water, start over at step 3 using less water. If it floats, use your pencil to push it underwater but don’t submerge any more of the pencil than absolutely necessary. Read the new volume and record it on the data table.

5. Calculate the volume of the object by subtracting the volume of the water (step 3) from the volume of the water plus object (step 4). Record the volume of the object on the data table.

6. Calculate the density of the object from its mass (step 2) and volume (step 5). Record the density on the data table.

7. Repeat this for each of the other objects in your bag.

8. As you are probably aware, airtight cases can easily be blown apart by small mistakes. To minimize the importance of such mistakes, repeat the density determinations on each of the objects at least three times to strengthen your case.

9. Look at your data including your calculated densities. What limitations do your data have? How do you think you could make up for these limitations?

**Part 3 Density comparison by Flotation**

In part two, the absolute density was determined. This can be useful but sometimes, as you may have demonstrated; there is not enough accuracy in the measuring devices to tell if two samples are different statistically. In this part of the experiment you will directly compare the densities of two objects by floating them in a density matched liquid.

1. Sign in your materials from part 2 if you have not already done so and then sign out some rubber fragments for part 3. Before adding the rubber fragments to the test tube, it is important that each piece of rubber be carefully examined and briefly sketched. This will allow the examiner to identify each fragment when placed in the mixture of ethanol and water.
2. A cleaned and dried sample of the rubber piece found at the scene should be placed in a test tube containing distilled water. Record in your notebook what you observe. Is the piece of rubber more or less dense than water? Now add the piece of rubber found on the suspect vehicles to the water. What happened? Record. Remove one of the pieces of rubber with a forceps. Now, slowly add 95% ethanol with a Pasteur pipette to the test tube already containing water until the piece of rubber becomes suspended in the test tube. Now the density of this rubber matches the density of the solution. Carefully add the other piece of rubber to this same test tube. Stir the test tube. What do you observe? What conclusions can you draw from this?
3. Repeat this density matching test with pieces of rubber from the suspect’s girlfriend’s vehicle and suspect’s mother’s vehicle.
4. Return your tire samples and check out four bags of plastic samples, three found on the suspect and one at the scene.

**Part 4: Physical Measurements of Plastic Fragments**

Recognizing that the more pieces of evidence that point toward a particular conclusion, the easier that conclusion is to defend, more evidence will be collected on evidentiary plastic fragments.

1. Physical matching: Lay your plastic evidence pieces out on labeled pieces of paper. Try to obtain a physical match between fragments if possible. That is, match letters (if present) or two fragments by fitting together any scratches on the fragments, or by some other piecing together of the fragments. Such a fracture match – a physical match of two fractures – is conclusive proof that they were once two pieces of the same piece of plastic. Record any physical matches in your notebook. As you do this, be sure to keep the evidence collected from the suspect separate from the evidence collected at the scene. Your evidence bags will be weighed as you check them in and out to verify evidence integrity.
2. Edge thickness: Compare the fragments by measurement of the thickness of the edges of the fragments. Use a micrometer for these measurements. Although the results may not be conclusive themselves, they may help the decision making process later. Record in your notebook.

**Part 5: Comparison of Headlamp Fragments by Flotation:**

Now you will compare the relative densities of the plastics in much the same way you compared the tire fragments in Part 3.

1. Place a clean, dry piece of plastic found at the scene into a test tube containing saturated sodium chloride (NaCl). Record in your notebook what you observe. Is the piece of plastic more or less dense than saturated NaCl? Slowly add distilled water with a Pasteur pipette to the test tube thoroughly mixing after each addition until the plastic particle is exactly suspended. If you add too much water so that the sample begins to sink, add a few more drops of the sodium chloride solution. Now the density of this plastic matches the density of the solution. Carefully add a piece of plastic from Bag A (suspect’s vehicle) to the test tube. Stir the test tube. What do you observe? What conclusions can you draw from this? Carefully remove the “A” evidence from the test tube, keeping the crime scene evidence still in the test tube and add the “B” (suspect’s girlfriend’s) evidence. Record your observations. Repeat for the “C” (suspect’s mother’s) evidence.
2. Discuss your data with your partner. If one or both partners wish to repeat an analysis, this may be done, time permitting.

Investigator #1 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Investigator #2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Lab Report Sheet to be turned in for grading**

**Pre-lab: (Complete this section before lab)**

1. **What are the major safety concerns for dealing with ethanol? \_\_\_\_\_\_\_\_\_\_\_\_\_**

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1. **What are the major safety concerns for dealing with sodium chloride? \_\_\_\_\_**

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1. **What is the purpose of this experiment?**
2. **What are the major steps that will be taken to achieve the purpose?**

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**Pre-lab instructor signature:**

**Lab**

**Part 1: Page(s) in lab notebook data can be found on: \_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. **Likely identification of object 1 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Reasoning: \_\_\_\_\_\_\_\_\_**
2. **Likely identification of object 2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Reasoning: \_\_\_\_\_\_\_\_\_\_**
3. **Likely identification of object 3 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Reasoning: \_\_\_\_\_\_\_\_\_\_**

**Part 2: Page(s) in lab notebook data can be found on: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

9. Look at your data including your calculated densities. What limitations do your data have? How do you think you could make up for these limitations?

**Part 3 Page(s) in lab notebook data can be found on: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. **What observations did you make when you compared the density of the rubber found at the scene with rubber found on the suspect’s vehicle? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**What conclusions can be drawn from this? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. **What observations did you make when you compared the density of the rubber found at the scene with the rubber found on the girl friend’s vehicle? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**What conclusions can be drawn from this? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. **What observations did you make when you compared the density of the rubber found at the scene with the rubber found on the mother’s vehicle? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**What conclusions can be drawn from this? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Part 4 Page(s) in lab notebook data can be found on: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Weight of bag at check-out \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Initials \_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Weight of bag at check-in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Initials \_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**What observations/ conclusions can be drawn from physical measurement of plastic fragments? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Part 5 Page(s) in lab notebook data can be found on: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. **What observations did you make when you compared the density of the plastic found at the scene with the plastic found on the suspect’s vehicle? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**What conclusions can be drawn from this? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. **What observations did you make when you compared the density of the plastic found at the scene with the plastic found on the mother’s vehicle? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**What conclusions can be drawn from this? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. **What observations did you make when you compared the density of the plastic found at the scene with the plastic found on the girl friend’s vehicle? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**What conclusions can be drawn from this? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Post-lab questions (Please type responses on a separate sheet of paper.)

1. Assume that in Part 2 The Density of Irregularly Shaped Objects your object floated and was therefore only partially submerged. Would this affect the value obtained for the object’s density? Explain. Can you suggest a better way to proceed?
2. A piece of jewelry was tested to determine if it was pure silver or a silver plated resin. The mass of the jewelry was 1.52g. A forensic chemist measured the volume displaced by the item then repeated the experiment. She obtained two different values, 0.16mL and 0.14mL. Calculate the density of this item using each volume amount. How do the experimentally obtained density values compare to that of pure silver? If we assume that the sample really was pure silver, how accurate and precise were the forensic scientist’s results?
3. The flotation methods you used in Parts 3 and 5 could not be used to ascertain the density of gold or silver jewelry. Explain why this statement is true.
4. Would you recommend the water displacement method for matching the density of a soil sample found at the scene of a crime with dirt from the bottom of a suspect’s shoe? Why or why not?
5. Speculate as to why 50% ethanol/ 50% water mixture was used in the tire sample comparisons rather than pure water which is cheaper and easier to work with.
6. What conclusions can you make about the suspects and their proximity to the crime scene? Back up your conclusions with data and explain any weaknesses in your data.
7. How are density differences used in forensic applications? Give a specific example. (Density has been used in glass, plastics, and bones) At the end of your answer, give any references you used to come up with your answer.

**Please attach the yellow pages from your notebook to the back of this report.**