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ABSTRACT

This guide presents learning activities and lesson plans that integrate science with technical and vocational areas. Activities and plans are organized under broad headings such as Environmental Science and Acid Rain Research; Criminal Justice, Chemistry, and Narcotics; Children's Education and Services; Cosmetology; and Health Professions. Students are able to explore the collection and testing of rainwater, use narcotic testing modalities, develop a science activity appropriate for elementary-aged children, investigate the general characteristics of their own hair, and test several brands of antacid tablets for their ability to neutralize excess stomach acid. All activities include procedures, materials lists, graph grids, and data sheets. (DDR)

Integrating Science with Technical and Vocational Areas

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Advanced Chemistry and Technical Area Integration Projects

Environmental Science: Acid Rain Research

Project Activities:

* Students will design a rainfall water collector - The environmental science instructor will advise you concerning construction of this device.
* Students will develop a groundwater collector.
* Students will make measurements of rainfall amounts and pH.
* Students will compile their results and prepare a written report
* Students will present to the Advanced Chemistry and/or the Environmental class the results of their research.
* Students will discuss the relevance of pH to their technical area.

Criminal Justice: Chemistry and Narcotics

Project Activities:

* Students will use narcotic testing modalities under the direction of the state crime lab supervisor or a local forensic science expert.
* Students will maintain written records of the tests used to classify different types of narcotics.
* Students will prepare a poster that diagrams one of the following:
    1) the classification of narcotics
    2) the types of chemical tests used to differentiate the different types of narcotics
    3) the effects of different narcotics
* Students will prepare and give an oral presentation dealing with one of the topics mentioned previously.
* Students will discuss the relevance of this study to their technical area.

Children's Education and Services:

Project Activities:

* Students will develop a science activity that is appropriate for elementary aged children.
* Students will review concepts to be taught from elementary teachers that are tied to state standards.
* Students will write a lesson plan dealing with the activity.
* Students will prepare and practice teach the activity to their chemistry and/or technical class.
* Students will visit an elementary school and present the activity to first and/or second graders.
* Students will discuss the relevance of science to their technical area.
* Students will self-evaluate their project by answering the following questions:
    1. What did you learn from this project?
    2. What did the children learn?
    3. What was the best part of this project?
    4. What would you change about this project for next year?

Cosmetology

Project Activities:

* Students will investigate the general characteristics of their own hair and test the effects of various hair cleansing and treating solutions on the properties of hair. Students will work in groups of two, testing the effects of a pH 4 solution, pH 8 solution, a permanent wave solution, or a permanent wave + neutralizer solution on the hair samples.
* In addition, students will perform similar tests on their own hair.
* Students will determine the amount lead present in a commercial hair color product.
* Students will maintain records of experimental results.
* The students will make a presentation of the results to their chemistry class. The students' presentation should include a description of the relationship of pH to the chemistry of hair.

Health Professions

Activities

* Students will test several brands of antacid tablets for their ability to neutralize excess stomach acid.
* Students will rank the antacid tablets based on amount of acid neutralized by mass and by cost.

Resources:

Criminal Justice: Forensic Science Activities

- "Forensic Laboratory Science and Detective Mystery Writing"; Flinn Scientific, Inc., PO Box 219, Batavia, IL 60510 Telephone Number: 708-879-6900.
- Kemtec Educational Corp., 9889 Crescent Park Drive, West Chester, OH 45069 makes science kits that can be purchased from science vendors. Sample kits include: Analysis of Fingerprints, Hair, Drugs and Poisons.
- Clue Finders, Inc., PO Box 20531, Tampa, FL 33622-0531: Blood Detection Kit.
- Various Internet sites are dedicated to Forensic Science Activities.
- Criminalistics: An Introduction to Forensic Science, 6th Edition by Richard Saferstein. Prentice Hall, 1998.
- Lab Manual Criminalistics: An Introduction to Forensic Science, 6th Edition by Richard Saferstein, Clifton Meloan, and Richard E. James. Prentice Hall, 1998.

Environmental Science

- Hach Co., PO Box 389, Loveland, CO 80539 Tel: 1-970-669-3050
- Lamotte Company, PO Box 329, Chestertown, MD 21620: Environmental Science Testing Kits
- Chemistry with CBL by Richard Holmquist, Jack Randall, and Donald L. Volz. Vernier Software, 8565 S.W. Beaverton-Hillsdale Hwy, Portland, OR 97225-2429.
- Access Excellence- Acid Rain Research- Internet Address: http://www.gene.com/ae/AE/AEC/AEF/1995/jones_rain.html

Cosmetology

- Chemistry in the Community, American Chemical Society, Kendall-Hunt Publishers. Laboratory Activity: Chemistry of Hair, Section D of Health Unit : Your Risks and Choices.
-
- Practical Chemistry Labs, A Resource Manual. J. Weston Walch Publishers, PO Box 658, Portland, Maine 04104-0658

Health Professions

- A source for the antacid activity can be found at the following Internet address: http://chem.csustan.edu/chemistry/chem1002/antacid.htm

Lesson Plan

Title:

Teacher:

Concept:

Age Group:

Objectives:

1. **The child will**

2. **The child will**

Materials Needed:

Preparation Required:

Introduction:

Activity Procedure:

Conclusion:

How child will be involved:

Date used:

Evaluation:

Source:

LESSON PLAN

TITLE: Homemade Rockets

CONCEPT: Chemical change **AGE GROUP:** elementary level

OBJECTIVES:

1. The child will use small-motor skills.
2. The child will practice eye-hand coordination.

MATERIALS NEEDED:

glass bottle with cork top
paper towels
vinegar
baking soda
straight pins
scissors
tissue paper or ribbons
paint or stickers

INTRODUCTION:

1. Introduce the activity.
2. Get out materials.
3. Explain procedure.
4. Demonstrate the activity.

ACTIVITY PROCEDURE:

1). Decorate the glass bottle with paint or stickers.

2). Use straight pins to attach bright strips of paper or ribbon to the cork.

3). Pour 1/2 cup vinegar into the bottle.

4). Cut a 5 inch square of paper towel. Pour 2 tablespoons baking soda into the center. Roll up the paper and twist the ends.

5). Get the cork wet.

6). Drop the rolled-up paper into the bottle. Quickly put the cork in the bottle, stand back, and watch your rocket launch.

CONCLUSION:

1. Explain concept learned.
2. Review procedures.
3. Clean-up.

HOW CHILD WILL BE INVOLVED:

The child will be able to perform all procedures with teachers assistance.

EVALUATION:

As the vinegar soaks into the paper towel, it mixes with the baking soda. Baking soda, a chemical called sodium bicarbonate, reacts with vinegar to produce a gas called carbon dioxide. The molecules in gas move faster and push each other apart. This causes pressure to build up in the rocket and the pressure launches the cork rocket.

LESSON PLAN

TITLE: Feely Bag

TEACHER: Ms. Carol

CONCEPT: Five Senses

AGE GROUP: First Graders

OBJECTIVES:

1. The child will realize that by using their sense of touch they can describe the product.

2. The child will learn how to identify the product by using their sense of touch.

MATERIALS NEEDED:
Blindfold/ Stickers
Cooler
Lettuce
Rice
Shoestrings
Feathers
Plastic Spoons
Sand

PREPARATION REQUIRED:
Tables set up, Feely bags ready

INTRODUCTION:
"What are the five senses?" (Point to: nose, ears, eyes, hands, and tongue - as they guess) "Today we are going to work with your sense of touch."

ACTIVITY PROCEDURE:
Introduce activity. Cover one child's eyes with stickers. have child stick hands in a bag and guess what they feel. Discuss what they feel and then tell them the product which they touched. Repeat with different item for each child. Clean up any mess with their help.

CONCLUSION:
What sense did we use? Does anyone remember?
Thank you for participating in this game with me.

HOW CHILD WILL BE INVOLVED:
The child will feel the substance within the bag and guess what it is.
The child will also help the teacher clean up the mess from their activity.

DATE USED

EVALUATION

Who Done It?

A Forensic Science Activity

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Bethelehem, PA

Julie Willey
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Delaware State Police Crime Lab
Dover, DE

Grade Level:
10 through 12

Goals:
Upon completion of this lesson, the student will:

1. Understand the application of chemistry to criminal investigation.
2. Work cooperatively in groups, using the scientific process.
3. Use real world laboratory techniques as a problem solving tool.
4. Solve a crime using deductive reasoning.

Specific Objectives:
Upon completion of this lesson, the student will be able to:

1. develop latent fingerprints using three different chemical techniques.
2. identify possible blood stains through the use of two chemical methods.

Introduction:

The purpose of this exercise is to expose the students to forensic science techniques and problem-solving. Forensic science is the application of scientific principles to law. Forensic science includes the disciplines of medicine, geology, chemistry, physics, and biology. This exercise will focus on the application of chemistry to the identification of fingerprints and to the presumptive testing of blood.

Special Note for Instructors:

This exercise can comprise a forensic science unit concerning the discussion of physical versus chemical methodologies for each problem-solving topic. Lessons from this and other forensic science units can then culminate in a final mock crime scene.

Safety -

Fingerprint Analysis:

Background

Fingerprints, usually found at the scene of a crime, are a very reliable means of identification. The activities that follow will focus on the methods used for obtaining latent fingerprints. Fingerprints left at the scene of a crime are classified as being visible, plastic, and/or latent. Visible fingerprints are formed by fingers touching colored materials such as paint, ink, blood, or grease. Plastic fingerprints are produced by fingers coming in contact with soft materials such as wax, soap, dust, or some other soft surface. Latent fingerprints are those that are caused by perspiration on the ridge impressions of the person's skin. These impressions are composed of sweat, glucose, lactic acid, peptide, ammonia, riboflavin, and inorganic salts of potassium and sodium. Different types of surfaces require special techniques to make the fingerprints visible. Fingerprints can be physically developed by using powders. Usually gray and black colored powders are used. The powders adhere to the oils and perspiration left on a surface. A record of the fingerprint can be made by photographing it or by lifting the impression with Scotch tape. The records of the prints are then studied by fingerprint experts in order to determine the owner of the prints.

The activities that follow will be used to demonstrate some of the chemical techniques used to develop latent fingerprints. The advantages and disadvantages of each technique can be compared at the end of the 3 activities. In addition the advantages of these chemistries can be compared to the physical methods . For example, dusting for fingerprints with powders is time-limiting in that the perspiration tends to dry and thus be less effective as an adsorbent for the powder.

Activity 1 - Cyanoacrylate Fuming

Cyanoacrylate fuming (also called the super glue method) is a proven and effective tool for obtaining latent fingerprints. This type of fingerprint development is a chemical method. The super glue reacts with fragments of amino acids, fatty acids, and proteins from the latent fingerprint along with moisture from the air making a visible white material that adheres to the ridges of the fingerprint. The final result is an impression of the fingerprint.

Materials

Elmer's Wonderbond (or other brand of "superglue")
Rit Fabric Dye (recommended colors are Navy Blue and Black)
0.5 N sodium hydroxide solution (20g NaOH per one liter of distilled H_20)
absorbent 100% cotton (gauze, cheesecloth, or cotton balls)
a glass microscope slide
a polyethylene (HDPE) article (e.g. a square cut from a plastic cup)
a polystyrene article (e.g. a section of a styrofoam cup)
a dessicator (the fuming chamber)

Saturate absorbent cotton (we used 2 x 2 in. gauze) with 0.5 N sodium hydroxide. Allow to dry completely. Apply approximately 2 g of the glue on the surface of the NaOH-treated dry pads and immediately place the lid on the dessicator. Within 10-15 seconds white fumes will be visible and the fuming will continure for approximately 1-1.5 minutes. The evidence should be exposed to the cyanoacrylate fumes in the enclosed chamber for at least 30 minutes. The latent print should develop as a white, sticky material

Activtiy 2- Ninhydrin

Ninhydrin reacts with amino acids, a substance found in perspiration. The ninhydrin will cause the amino acids to turn purple, providing a visual impression of the print. The object to be sprayed is usually paper or wood products which do not work well with powders.

Activity 3 - Iodine

Iodine is an element that will vaporize quite readily. It will vaporize from the heat of your hand. The iodine vapor produced will react with fats in fingerprints to

Introduction - Presumptive Test for Blood

Special Note to Teachers: This laboratory activity does not use human blood. Animal blood, beef liver, was used for development of this experiment. Blood used for blood typing experiments can be used for this activity. See various chemical suppliers.

In this activity, students will be testing samples of various materials in order to determine if they consist of blood. To determine if a blood spot or stain has been deposited at the scene of a crime, a presumptive blood test is used. The presumptive test will only indicate that a possibility exists that the spot or stain might be blood. Further investigation would be needed to determine if the blood is animal or human.

The tests used are based on an oxidation reaction of hydrogen peroxide with another chemical substance. The result of each reaction is a vivid color change. The reaction is catalyzed by the presence of the heme group in hemoglobin. Any reaction that takes place after 15 seconds should be ignored, because sunlight and exposure to the air can cause auto-oxidation. It should be noted that several vegetable or inorganic materials can produce a similar reaction as the phenolphthalein and TMB tests. For this reason, these tests are known as presumptive tests. Further testing must be used to determine if the stain is blood.

Activity 1 - Phenolphthalein Test

Teacher Preparation:

a. Prepare strips of textile material (gauze bandages work fine) with have been individually stained with the materials listed in the data table below. The instructor can also make stains of the materials on different types of surfaces, such as glass, metal, or ceramic.

b. Preparation of reduced phenolphthalein - Reduced phenolphthalein is really a solution of phenolphthalin. The solution is produced by adding 2 grrams of phenolphthalein, 20 g KOH (or NaOH), 20 g Zn granule, and 100 ml of distilled to a 500 ml round bottomed flask and boiling chips or glass beads. Secure the flask to a reflux apparatus. Phenolphthalein in the reduced form is available from Clue-Finders, Inc. (tel. 1-813-207-007).

c. Gently reflux the solution for 2 to 4 hours or until the solution becomes colorless. The solution produced is reduced phenolphthalein, phenolphthalin.

d. Store the solution in refrigerator over zinc granules.

e. For each group of students, prepare 3 labeled Beral pipets, one labeled for ethyl alcohol, one for phenolphthalein, and one for hydrogen peroxide.

Student Experiment

1. Make a small cutting of the blood stain. Place the cutting on a piece of filter paper.

2. Add 1 drop of ethyl alcohol to the small cutting, followed with 1 drop of reduced phenolphthalein solution. Note any reaction. Note: Any color change during this step should be ignored.

3. Add 1 drop of 3% hydrogen peroxide. Note any color change that takes place within 15 seconds. Record your observations in the data table.
   Teacher Note: A vivid pink color should be interpreted as a positive test.

4. Repeat Steps 1-3 for each of the other stains.

Procedures for materials on hard surfaces:

5. Gently rub the outer edge of a questioned stain with a cotton swab moistened with distilled water. Add 1 drop of ethyl alcohol to the swab followed by 1 drop of reduced phenolphthalein solution. Note any reaction, however disregard any color change.

6. Add 1 drop of 3% hydrogen peroxide. Note any color change that takes place within 15 seconds. Record your observations in the data table.
   Teacher Note: A vivid pink color should develop within 15 seconds.

	Phenolphthalein			
Item Tested/Surface	**cutting**	**glass**	**metal**	**ceramic**
Blood				
Coffee				
Rust				
Ketchup				
Tea				
Vanilla				
Coke or Pepsi				
Bleach				
A-1 Sauce				
Ink				

Activity 2 - TMB (tetramethylbenzidine) Test

1. Make a small cutting of the blood stain. Place the cutting on a piece of filter paper.

2. Add 1 drop of TMB solution to the rubbing and cutting. Note any reaction. Note: Any color change should be ignored.

3. Add 1 drop of 3% hydrogen peroxide. Note any color change that takes place within 15 seconds. Record your observations in the data table.
Teacher Note: A vivid blue green color should develop.

4. Repeat steps 1-3 for the other stains.

Procedures for materials on hard surfaces:

5. Gently rub the outer edge of a questioned stain with a cotton swab moistened with distilled water. Add 1 drop of TMB. Note any reaction, however disregard any color change.

6. Add 1 drop of 3% hydrogen peroxide. Note any color change that takes place within 15 seconds. Record your observations in the data table.
Teacher Note: A vivid blue green color should develop.

	Tetramethylbenzidine, TMB			
Item Tested/Surface	**cutting**	**glass**	**metal**	**ceramic**
Blood				
Coffee				
Rust				
Ketchup				
Bleach				
Vanilla				
Coke or Pepsi				
Tea				
A-1 Sauce				
Ink				

Discussion and Conclusions:

1. Use the Internet or reference sources to find the types of fingerprint patterns that are used for identification.

2. Describe the differences between a Superglue print, a ninhydrin exposed print, and a print exposed to iodine.

3. Which of the methods described in #2 are the most effective? What factors influence the effectiveness of the techniques used?

4. Why would substances other than blood produce results similar to blood when using the phenolphthalein and TMB tests?

Identification of Glass Fragments by Density

Background:

Broken glass sometimes will be found at the scene of a crime. Broken fragments of the glass may have carried away by the person committing the crime. Being able to identify the glass at the scene may provide valuable physical evidence that may help determine who committed the crime.

Activity:

This activity will be used to determine the density of a piece of glass by the water displacement technique. Note: This activity can be used to determine the density of materials other than glass.

Equipment

Balance: +/- 0.01 g or better which has attachment for determining density by water displacement.
Scissors and String: 1 meter
Small beakers : 250 ml or smaller
Small pieces of glass or other materials (check at a recycling center for assistance)
Iron ring and support stand

Method

1. Attach a piece of string to a piece of glass. Attach this combination to the hook on the balance.

2. Weigh the piece of glass in the air to the nearest 0.01 g. Record this amount.

3. Fill a beaker nearly full with water. Suspend the glass and string so that the glass is completely immersed in the water.

4. Weigh the glass in the water to nearest 0.01 g and record.

5. Determine the density of the glass according to the relationship:

$$\text{Density of object} = \frac{\text{weight of object in air}}{\text{loss of weight in water}}$$

6. Repeat this procedure for other types of glass.

7. Use the Internet or other resource to determine the densities of various types of glass, ceramics, or other materials used in this activity.

Extension - "Mock Crime Scene"

Divide the class into the following groups of students:

1. Interview Team- will interview any witnesses and/or suspects.
2. Fingerprint Team- will investigate and collect fingerprints.
3. Physical Evidence Team- will collect any other evidence
4. Photography Team - not necessary, make a photographic log of the crime scene (use a video camera instead of taking individual photos).
5. Sketching Team- Diagram the area of the scene, take measurements of the area. This activity would be a good opportunity to integrate drafting with science. The drafting students could produce a detailed diagram of the scene with appropriate dimensions and labels.
6. Possible suspects- added interest, use faculty members.

Prior to actually doing the mock crime scene, each of the groups listed above should meet to discuss what they will be doing during the mock crime scene analysis. All the students need to know beforehand is that they will be investigating the scene of a burglary.

List items needed for the crime scene

Room for the mock crime scene
Evidence left at the scene: broken glass; stains, blood, etc; fingerprints.
Other physical evidence that the instructor deems important.
Materials necessary for analyzing evidence: see previous activities.
Known fingerprints of possible suspects.

Provide students with the following scenario:
"The following verbal report was given to the forensic investigation team as they arrived at the scene of the crime. A suspected burglary has occurred at X, Y, Z, Inc. A window was found to be broken with glass on the floor. A substance found near the broken glass appears to be blood. Several 100 dollars are missing from the company cash box which is kept in the desk of a secretary. A witness did happen to see an individual leave the building shortly after the break-in was noticed.

Students:

Working in teams the students will investigate the scene of the crime. Evidence should be gathered and interviews conducted. After the evidence has been tested and all suspects interviewed. The members of the teams should work together and determine who is the prime suspect. Detailed notes, reports of evidence test results, and written reports detailing how conclusions were drawn as to the identity of the suspect will be used as an evaluation.

Further Extension:

The information derived from the mock crime scene investigation could be used as a basis for a mock trial. This activity could be integrated with a social studies class. The evidence and other information could be collected by the chemistry class and the trial could be conducted in the social studies class. This activity will give the students the opportunity to make oral presentations, provide examples of their writing skills, and reinforce their reasoning and problem solving skills.

References

Kendall, Frank, and Rehn, Burton. Rapid Method of Super Glue Fuming Application for the Development of Latent Fingerprints, pp. 777-780, Journal of Forensic Sciences, Vol. 28, No. 3, July, 1983.

Pennsylvania State Police. **PSP Serology Procedures Manual**, pp.2-3 through 2-13, 1996.

Saferstein, Richard. **Criminalisitics- An Introduction to Forensic Science** (6th edition). Upper Saddle River: Prentice Hall, 1997.

http://chem.csustan.edu/chemistry/chem1002/antacid.htm

The Neutralizing Ability of Antacid Tablets

Purpose: In this experiment you will measure the amount of stomach acid consumed (or neutralized) by various antacid tablets. If you have a favorite one, bring a package to the lab (one color only).

Procedure: This experiment involves several steps. First the tablet is dissolved and an excess of acid of known concentration is added to the tablet. The solution is then briefly heated to insure that all of the antacid reacts. Finally, the remaining unreacted acid is titrated with base (NaOH) to determine the amount left over and hence, the amount that reacted with the tablet. The chemical reaction which occurs is:

$$NaOH + HCl \text{ -------> } NaCl + H_2O$$

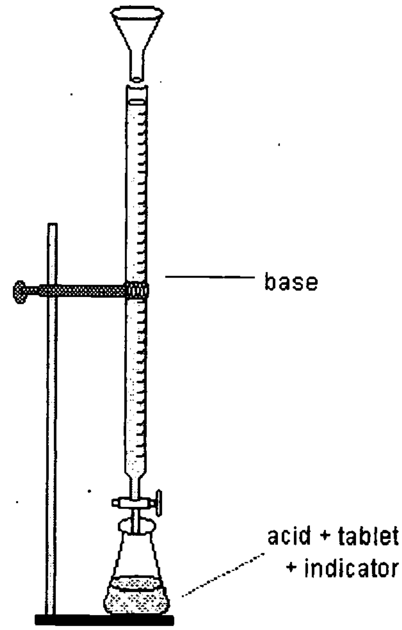
A detailed description of the individual steps in the analysis follows.

Preparation of Sample:

1. Weigh an antacid tablet and transfer it to a 250 ml erlenmeyer flask. Record the weight of the tablets you are going to analyze.
2. Add 50.0 ml of hydrochloric acid solution (labeled 0.50 M) with a pipette to the flask containing the tablet.
3. If the tablet does not dissolve readily, cover the flask with a watch glass and boil gently for 5-10 minutes on a hotplate. Set it aside to cool. While it's cooling, weigh out another tablet of the same brand and proceed through steps 1 and 2.

The Titration:

1. Check out a buret from the Stockroom. Test it to see if it is clean by filling with distilled water and letting it drain. If the water does not drain from the walls, wash carefully ($$$) with warm, soapy water using a buret brush. Rinse several times with distilled water.
2. Using a funnel fill the buret with base (sodium hydroxide) solution (labeled 0.5 M) to just above the top line.



3. Allow it to drain to just below the top line. If air bubbles remain in the tip, drain more out. If they still are in the tip, your instructor--who is lurking nearby, will be happy to get them out for you.
4. Add several drops of the indicator, thymol blue, to the cooled solution of antacid tablet containing unreacted acid. The solution will be red.
5. Read the initial volume of the buret using the graduations on the buret and bottom of the meniscus. It is often easiest to put a white piece of paper behind the buret to sight against. Record this as the initial volume for the first trial in your notebook in the results section.
6. Add a small amount (less than one milliliter) of the sodium hydroxide to the flask. A spot of colorless solution may appear where the drops hit. With swirling, this area will disappear. The idea is to add the exact amount of the base solution needed to cause the solution in the beaker to change from red to very pale yellow and stay yellow for 15 seconds or more. This is harder than it may sound. The color change should be observed with the addition of only one or two drops of the base solution and you can't go back if you add too much. Watch the solution in the flask. As it gets more difficult to get rid of the pinkish color when you swirl the flask, add smaller amounts. Ideally, you should be adding it dropwise when you reach the point where color finally changes from red to yellow (endpoint). Patience! The first time is the hardest. Once you know how much it takes for a tablet, you can add slightly less in the next trial and add the last milliliter or so dropwise and you won't go past the endpoint. It may be necessary to refill the buret once.
7. Read and record the final volume. Calculate the total volume you used by subtracting the initial from the final volume. Record this, too, in your notebook.
8. As time permits, do one or two more trials. They should, as you practice, agree to within about 0.20 ml.

Wastes: The HCl and NaOH used in this experiment are weak. They can be put into the sink with the water running. The finished titrations are not hazardous and can also be rinsed down the drain.

The Calculations: The number of grams of stomach acid that is neutralized can be calculated using the expression:

$$\text{grams stomach acid per tablet} = 10[\ 25.0 - (\text{ml base})(.50)\ ]$$

If, for example, it took 8.0 ml of base to titrate the sample, then

$$\text{grams stomach acid} = 10[\ (25.0) - 8.0\ (.50)\ ] = 210\ \text{g}$$

Record the value for each of your samples and the average value with your **results**.

Conclusion: Does your tablet neutralize 47 times its weight in stomach acid? You can answer this question for your conclusion by dividing the mass of stomach acid by the mass of the individual tablet.

Speed Lab

Each day on our highways police officers are responsible for monitoring and enforcing the speed limit. In order to do this they must be able to measure the speed of a vehicle quickly and accurately. In this lab we will be looking at two of the methods that are commonly used to measure speed.

Equipment

Tape
Stopwatch
Yardstick (meterstick) or Tapemeasure
Radar Gun

Part 1 - Calculating Speed

Procedure

1. Place one piece of tape on the ground to mark the starting point. Measure 50 ft. and place another piece of tape on the ground to mark the end point.
2. Each person in the group will move from the starting point to the end point while being timed. Some members should walk and some should run in order to obtain a variety of times.
3. Continue this procedure until you have recorded 8 times of varying length. Each person must participate by being timed at least once.
4. Record the results in Data Table 1.

Data Table 1

Name	Time	Speed ft/sec	Speed mi/hr	Speed m/sec	Speed Km/hr

Calculations

1. Calculate speed for each person from trial 1 in ft/sec and record in data table 1.

2. Convert speed for each person in trial 1 from ft/sec to mi/hr and record in data table 1.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} \qquad 1 \text{ mi/hr} = 1.47 \text{ ft/sec}$$

3. Convert speed for each person from English units to SI units of m/sec and Km/hr.

$$1 \text{ meter} = 3.3 \text{ feet} \qquad 1 \text{ Kilometer} = 1{,}000 \text{ meters}$$

Part 2 - <u>Measuring Speed with Radar</u>

Procedure

1. Each person will again run 50 ft. while being timed. Record times in Data Table 2.

2. During each persons run, the instructor will measure their speed with the radar gun. Record in data table 2.

3. Calculate each persons speed in mi/hr. and record in data table 2.

Data Table 2

Name	Time	Speed Calculated	Speed Radar

Questions

1. Describe how a police officer could use method number 1 in catching speeders.

2. Is there a difference in the calculated speed and Radar measured speed in Part 2.

3. The world record for running 100 meters was set by Donovan Bailey at 9.84 seconds. The world record for running the mile was set by Noured Morceli at 3 minutes 44 seconds. The world record for running the marathon (26.2 miles) was set by Belayneh Dinsamo at 2 hours 6 minutes and 50 seconds. Calculate the speed of each of these runners in both ft/sec and in mi/hr. Would they be speeding if they ran past your school?

1 mile = 5280 ft   1 mi/hr = 1.47 ft/sec   1 meter = 3.3 feet

Traffic Accident Reconstruction Resources

Institute of Police Technology and Management

http://www.unf.edu/iptm/

Best source for information on accident reconstruction. Includes books, videos, articles and courses in accident reconstruction.

The Traffic Accident Reconstruction Origin-Web Page

http://www.tarorigin.com/index.html

Web page with useful information on accident reconstruction. Includes a listing of other resources and links. Also contains a section with real accidents that you may submit reconstruction solutions to along with other peoples solutions and supporting information.

PASCO Scientific

http:www.pasco.com/home.htm

Computer software and scientific equipment supplier. Claim to have simulation software capable of simulation of collisions and their affects.

"Squeal Those Tires!", Linda Griffin Cables, *The Mathematics Teacher*, Vol. 85, No. 1, January 1992. This article describes how to set up a mock accident and the calculations necessary to thoroughly investigate the accident.

Thermal Resistance Project

Over the course of the next few weeks we will be investigating the principles of Thermal Resistance. Upon completion of the unit each person will be responsible for creating a thermal resistance container. This container should be made using the ideas and principles which we will be studying. Each container will be tested for its overall thermal resistance. The student who creates the container with the highest thermal resistance will receive bonus points for their efforts.

Project Rules

1. Container must fit into a space 12 in. x 12 in. x 12 in.
2. Container must have an interior space of 4 in. x 4 in. in width and 5 in. high.
3. Materials used in construction must be used, recycled, discarded or have little monetary value.
4. Container must have a reusable lid or opening and it must be possible to run a thermocouple wire to the interior space.
5. Container may not be made from existing thermal containers. (Example - Cooler, Thermos, etc.).
6. No heat producing materials may be used.

In addition to the container itself each student will be responsible for writing a one page explanation of their containers construction. This explanation should include a description of the materials used, a description of the structure, and the reasoning behind the choices made.

Grading

The overall grade will consist of the following:

20% - Explanation
80% - Container

Grading of the container will be based on the following:

1. Effort in Construction
2. Thermal Resistance Qualities
3. Creativity

Thermal Container Test

Constructed By_______________________________
Tested By___________________________________

Procedure:

1. Obtain student container from instructor
2. Bring 300 ml of water to boil on a hot plate.
3. Place an empty beaker in the thermal container.
4. Pour hot water into beaker within container.
5. Place thermocouple probe in hot water and seal container lid.
6. Take thermocouple readings each minute for a total of 20 minutes. Record results in data table 1.
7. Measure room temperature and record in data table 2.
8. Find room temperature thermocouple voltage on thermocouple table and record in data table 2.
9. Add thermocouple voltage to room temperature voltage. Record result in data table 1 as total thermocouple voltage.
10. Find the equivalent water temperature by finding the total thermocouple result on the thermocouple table. Record results in data table 1.

Data Table 1

Time	Thermocouple Voltage	Total Thermocouple Voltage	Water Temperature
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Data Table 2

Room Temperature	Room Temperature Voltage

Chromel - Constantan Thermocouple Calibration Table

	0 °C	2 °C	4 °C	6 °C	8 °C	10 °C
–20 °C	–1.15 mV	–1.26 mV	–1.38 mV	–1.49 mV	–1.60 mV	–1.71 mV
-10 °C	–0.58	–0.70	–0.81	–0.93	–1.04	–1.15
0 °C	0.00	–0.12	–0.23	–0.35	–0.47	–0.58
0 °C	0.00	0.12	0.23	0.35	0.47	0.58
10 °C	0.59	0.71	0.83	0.95	1.07	1.19
20 °C	1.19	1.31	1.43	1.56	1.68	1.80
30 °C	1.80	1.92	2.05	2.17	2.30	2.42
40 °C	2.42	2.54	2.67	2.80	2.92	3.05
50 °C	3.05	3.17	3.30	3.43	3.56	3.68
60 °C	3.68	3.81	3.94	4.07	4.20	4.33
70 °C	4.33	4.46	4.59	4.72	4.85	4.98
80 °C	4.98	5.12	5.25	5.38	5.51	5.65
90 °C	5.65	5.78	5.91	6.05	6.18	6.32
100 °C	6.32	6.45	6.59	6.72	6.86	7.00
•	•	•	•	•	•	•
•	•	•	•	•	•	•
•	•	•	•	•	•	•
280 °C	19.48	19.64	19.79	19.95	20.10	20.26
290 °C	20.26	20.41	20.57	20.72	20.88	21.03
300 °C	21.03	21.19	21.35	21.50	21.66	21.81
310 °C	21.81	21.97	22.13	22.28	22.44	22.60
320 °C	22.60	22.75	22.91	23.07	23.23	23.38

Calculations

1. Find the temperature change for the water in container. This is equal to the difference between the initial and final water temperature for each container.

$$\Delta T_{water} = T_{initial} - T_{final}$$

ΔT = ____________________

2. The time for the temperature change was 20 minutes. Convert this to seconds, and record the value below.

T = ____________________sec

Water has a density of 1 gm/cm. Therefore, the mass of water expressed in grams is equal to the volume expressed in milliliters.

m_{water} = 300 grams

The specific heat of water is shown below.

$$c = \frac{1 \text{ cal}}{\text{gm C}}$$

3. Find the heat flow rate for each container.

$$Q_H = \frac{(m_{water})\ (c)\ (\Delta T_{water})}{t}$$

Where Q_H = heat flow rate in cal/sec

m_{water} = mass of water

$c = 1.0 \ \frac{\text{cal}}{\text{gm } C^{\circ}}$ specific heat of water

ΔT_{water} = temperature change of water

t = time for temperature change in sec.

Q_H = ____________________________

Approximate the temperature difference across the container. Do this by finding the difference between the average water temperature for each container assembly and the room temperature:

$$T = T_{avg} - T_{room}$$

T = ____________________

Find the thermal resistance of each container assembly, using the equation below.

$$R_T = \frac{T}{Q_H}$$

Where: R_T = thermal resistance in $\frac{C}{cal/sec}$

T = temperature difference across the container

Q_H = heat flow rate in cal/sec

R_T = ____________________

Name________________________
Date________________________
Period________________________
Lab Partners________________________

Density - Specific Gravity Project

PART 1

INTRODUCTION

During this project you will be exploring the principles of Density and Specific Gravity and their value in identifying materials. In part one you will identify different species of wood by calculating their density/specific gravity and comparing it to a list of known densities. In part two you will be identifying different metals by calculating their densities and comparing them to a list of known densities.

Finally in part three you will be using a hydrometer to measure the specific gravities of unknown liquids. You will then use this information to identify these unknowns.

DETERMINING SPECIFIC GRAVITY OF WOODS

PROCEDURE: Read all instructions prior to performing the activity.

1. Measure each block of wood to determine the length, width, and thickness in Centimeters.

2. Using the triple beam balance, determine the mass of each block in grams. Record the results in the table below.

3. Find the density of each block of wood. Remember Density = Mass/Volume.

4. Calculate the specific gravity for each block of wood and record the results in the table below.

5. Determine the species of each block according to the specific gravity of each block.

KNOWN DENSITIES OF WOOD SPECIES

1. Mahogany-
2. Red Oak-
3. White Oak-
4. Pine-
5. Western Red Cedar-
6. Red Wood-
7. Poplar-
8. Maple-

BLOCK	LENGTH	WIDTH	THICK	VOL.	MASS	DENSITY/S.G
1						
2						
3						
4						
5						
6						
7						
8						

BLOCK	SPECIES
1	
2	
3	
4	
5	
6	
7	
8	

<u>QUESTIONS</u>

1. How could this method be valuable to people working with wood?

2. Would all of these samples float if placed in water?

3. Would moisture content in wood affect density? How?

PART 2

DETERMINING SPECIFIC GRAVITY OF METALS

In this lab you will determine the volume, mass, density and specific gravity of five different metal samples. You will compare your calculated specific gravity to the actual specific gravity and determine the percent of error.

PROCEDURE: Read all instructions prior to performing the activity.

1. Using the triple beam balance, determine the mass of each metal sample in grams. Record your results in data table one.

2. Fill a graduated cylinder half way with water. Record the initial volume of the water only in data table one.

3. Slightly tilt the graduated cylinder and slide the sample to the bottom. Make sure the sample is completely emersed in the water. Record the volume of the water and the sample as the final volume in data table one.

4. Subtract the initial volume from the final volume to determine the volume of the sample. Record your results in data table one.

DATA TABLE ONE

METAL	INITIAL VOL.	FINAL VOL.	VOL OF SAMPLE	MASS
TIN				
ALUMINUM				
STEEL				
COPPER				
LEAD				

5. Find the density of each sample as follows and record your results in data table two.

$$\text{DENSITY} = \frac{\text{MASS}}{\text{VOLUME}}$$

6. Determine the specific gravity as follows and enter your results in data table two.

$$\text{S.G.} = \frac{\text{DENSITY OF OBJECT}}{\text{DENSITY OF WATER}}$$

7. Compare your calculated specific gravity with the actual specific gravity for each sample. Determine the percent of error as follows and record your results in data table two.

$$\% \text{ ERROR} = \frac{\text{SAMPLE VALUE - ACTUAL VALUE}}{\text{ACTUAL VALUE}} \times 100\%$$

DATA TABLE TWO

METAL	DENSITY	CALCULATED S.G.	ACTUAL S.G.	PERCENT OF ERROR
TIN			7.3	
ALUMINUM			2.7	
STEEL			7.8	
COPPER			8.9	
LEAD			11.3	

QUESTIONS

1. List three possible sources of error.

2. Why did you tilt the graduated cylinder and slide the sample into it? How could this procedure affect the percent of error?

3. How did the procedure for finding the density of wood in part one differ from the procedure for finding the density of metals in part two?

PART 3

DETERMINING SPECIFIC GRAVITY OF LIQUIDS

PROCEDURE: Read all instructions prior to performing the activity.

1. Obtain cylinder of unknown liquid from instructor.

2. Place light hydrometer in cylinder read specific gravity from scale on hydrometer and record in data table. If hydrometer floats above scale remove from cylinder and replace with heavy hydrometer. Read specific gravity from the scale and record in the data table.

3. Return unknown liquid to instructor and obtain new unknown liquid.

4. Repeat steps 1-3 until specific gravity of all 7 liquids has been measured.

5. Compare unknown results to list of known densities and identify each sample.

6. Rank samples from most dense (1) to least dense (7).

KNOWN DENSITIES OF LIQUIDS

1. Water
2. Alcohol
3. 50% Alcohol
4. Anti-freeze
5. 50% Anti-freeze
6. Windshield Wiper-Fluid
7. Salt Water

Liquid Number	Specific Gravity	Identification	Density Rank

QUESTIONS

1. What principle are we using to measure specific gravity?

2. How could automotive technicians use this principle to test Anti-freeze?

3. Would you float more easily in Alcohol or Anti-freeze?

Acceleration Lab

Acceleration is any change is speed of a moving object. In this lab we will be measuring the acceleration of a car over a measured distance.

Equipment

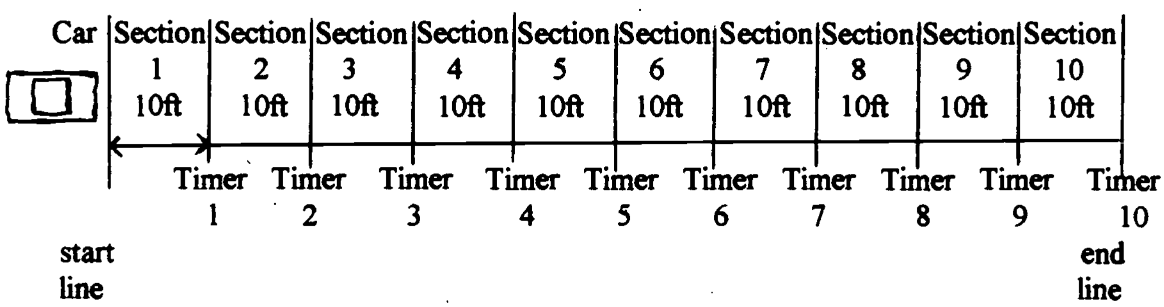
automobile
11 stop watches
tape
tape measure

Procedure

1. Place a line of tape on the ground.

2. Measure ten feet and place a mark with tape on ground. Continue this process until you have 10 sections each 10 ft in length. See diagram 1.

Diagram 1



3. Move car to start line. Car must be turned off and placed in neutral. Driver must stay in car for braking and safety.

4. Position 1 person at end of each section with a stop watch.

5. 3 people will get behind car and when signaled they will begin to push. The people behind car will push until they reach the fifth section at which time they will stop and allow car to coast through the next 5 sections.

6. At the signal to start each of the 10 timers will begin their stopwatches. As the car reaches the line at the end of each section that timer will stop their watch. Record these times in Data Table 1.

Data Table 1

Timer	1	2	3	4	5
Time at end of section					

Timer	6	7	8	9	10
Time at end of section					

Calculations

1. Calculate the time required to cross each section. Do this by subtracting the time at the beginning of each section from the time at the end of that section. Record results in data table 2.

Data Table 2

Section	1	2	3	4	5
Time per section (sec)					
Speed ft/sec.					
Acceleration ft/sec.					

Section	6	7	8	9	10
Time per section (sec)					
Speed ft/sec.					
Acceleration ft/sec.					

2. Calculate the speed for each section by dividing the distance of each section by the time for each section. Record in data table 2.

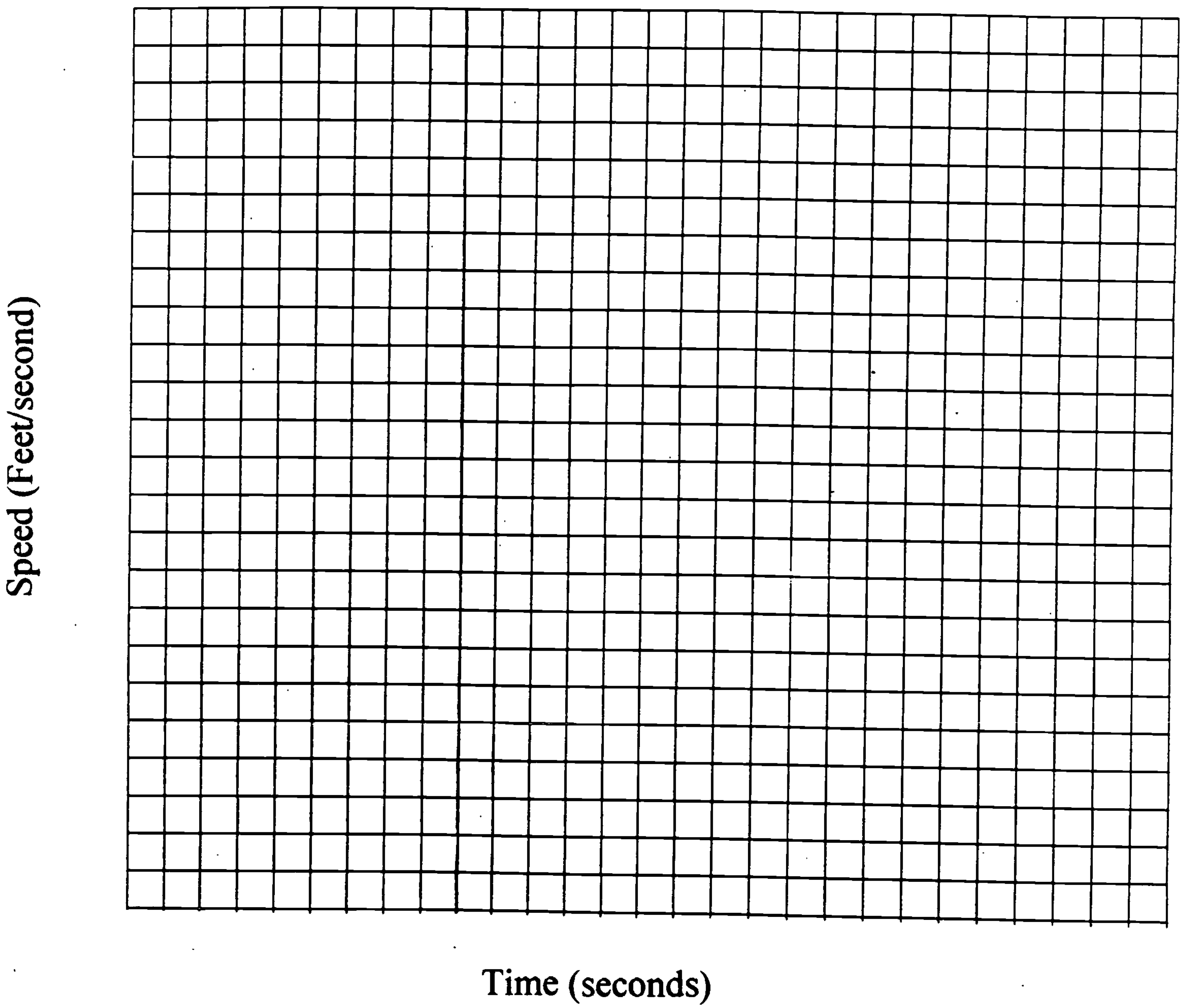
$V = \frac{l}{t}$ speed = $\frac{\text{distance}}{\text{time}}$

3. Calculate the acceleration for each section by subtracting the initial speed (the speed of the previous section) from the final speed (the speed of that section) and dividing by time. Record in data table 2.

$$A = \frac{Vf - Vi}{t} \qquad \text{acceleration} = \frac{\text{final speed - initial speed}}{\text{time}}$$

4. Draw an acceleration graph by graphing speed versus time

Acceleration Graph



Questions

1. In What section was acceleration the greatest? Why?

2. In what sections was the acceleration negative? Why?

3. Was the acceleration uniform? (see graph) Explain.

ACCELERATION ACTIVITY

1. In your own words, define acceleration.

2. Describe how it feels as a car is accelerating from a stopped postion to a speed of 60 m.p.h.

3. Examine the graph of the "Acceleration of a Car with an Automatic Transmission".

   What is shown on the x-axis?______________________________

   What is shown on the y-axis?______________________________

   Does a car have a <u>constant</u> acceleration?________________________

   Why or why not?

   How many gears does this car have?__________________________

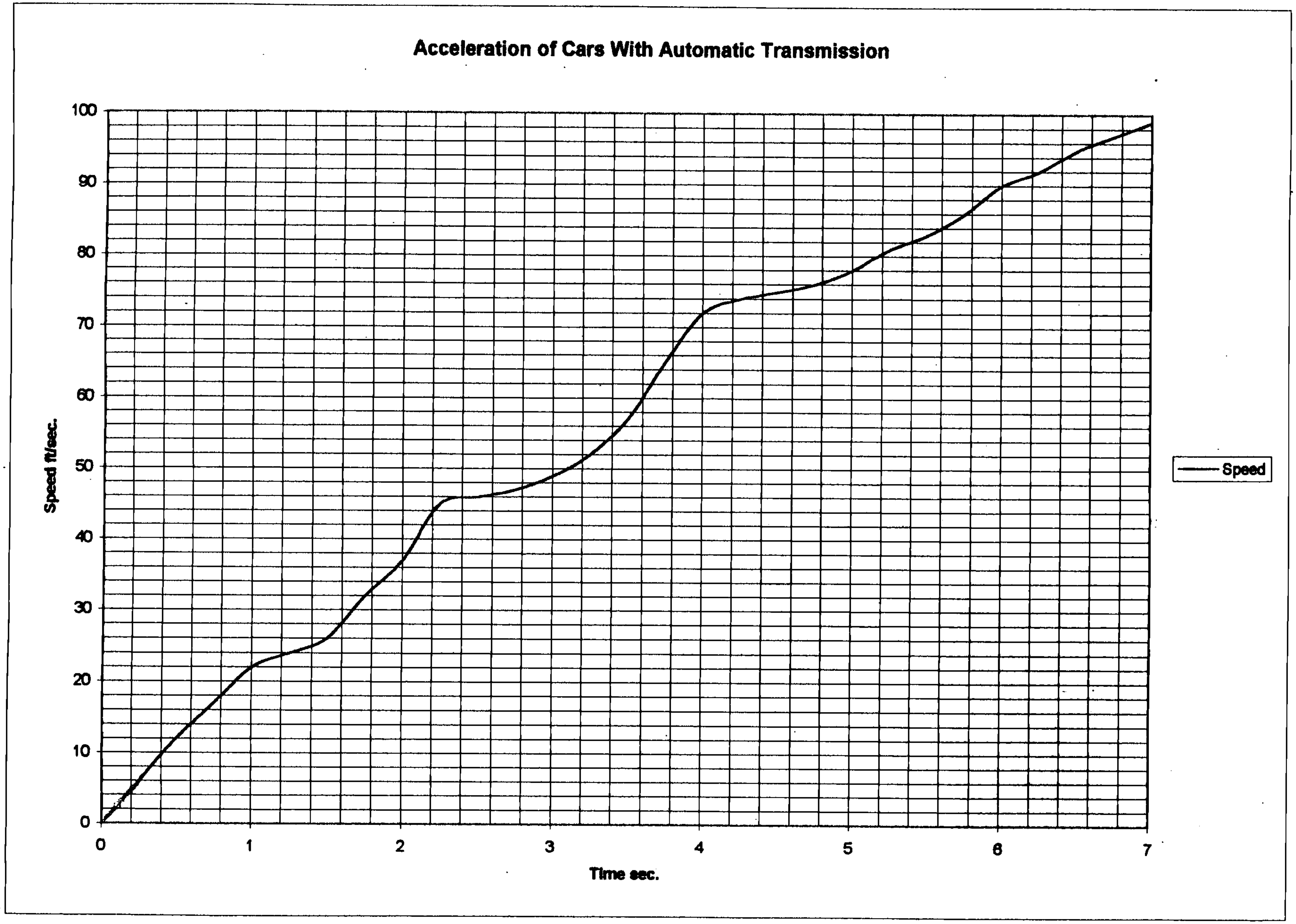
4. Look at the graph an find the acceleration that occurs as the car changes gears. ("How?" you say. Read on.)

   Since acceleration is a <u>change</u> in speed, you can use the slope of the line to describe the change. Remember the formula for slope? Write it below.

   Slope =

   A steeper slope means more acceleration. A flatter slope means less acceleration. Calculate the slope for each gear and don't forget to add the correct unit to your answer. (Show all your work!)

   In which gear will the car accelerate the most?________________________


Acceleration of Cars With Automatic Transmission
Speed ft/sec.
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
Time sec.
Speed

Power in Mechanical Systems

Power is the "rate of doing work". In other words whenever I do work, the time it takes to complete the task determines how "powerful" I am. In this activity we will determine how much power you truly have.

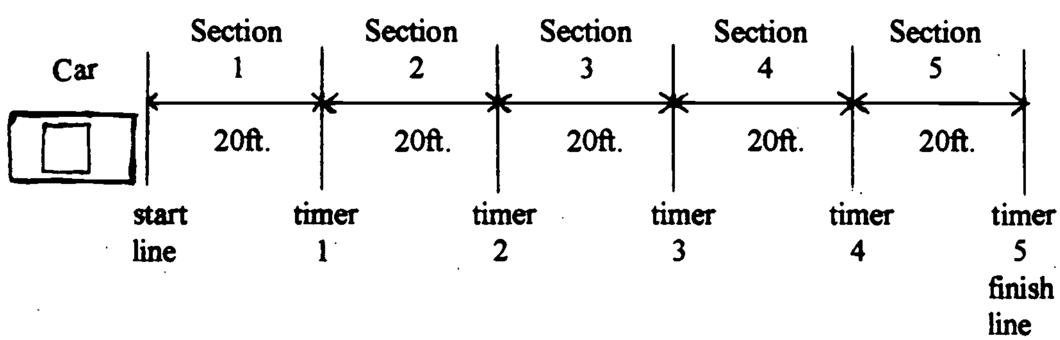
Equipment - automobile
5 stopwatches
tape
3 bathroom scales
3 towels
tape measure

Procedure -

1. Place line of tape on ground as starting line.

2. Measure five sections each 20 ft. long and mark each with a piece of tape. The last mark will be the finish line. (see diagram 1)

Diagram 1



3. Move car to starting line. Car must be turned off and placed in neutral. Driver must stay in car for braking and safety.

4. Place one person with each of the bathroom scales at the rear of the car. Place the towel between the scale and the car and prepare to push.

5. Position one person at the end of each 20 ft. section with a stopwatch.

6. Have one person at the start line as starter. At the signal each person at the rear of the car will push on the scale with a force of 25 lb. (this may be increased if necessary but should remain constant through each trial) At the start signal each timer should begin his stopwatch.

7. Pushers will continue pushing car with constant force through entire course. As the car passes each 20 ft. mark the timer at that section will stop his watch. Record times in Data Table 1. Record force and distance in data table 2.

Data Table 1

Section	1	2	3	4	5
Time at the End					

Data Table 2

Section	1	2	3	4	5
Force Applied					
Time for Section					
Distance					
Power					
Horse Power					

Calculations

1. Calculate the time for each 20 ft. section by subtracting the time at that point from the time of the section before. Record in Data Table 2.

2. Calculate the power for each section in $\frac{\text{ft. x lb.}}{\text{Sec.}}$ Record in Data Table 2.

   $$\text{Power} = \frac{\text{Force x Distance}}{\text{time}}$$

3. Convert power in $\frac{\text{ft. x lb.}}{\text{Sec.}}$ into Horsepower and record in Data Table 2.

   $550\ \frac{\text{ft. x lb.}}{\text{Sec.}} = 1$ horsepower.

Questions

1. How did power change as you moved through course?

2. In which section was power the highest? In which was it the lowest?

3. Why did power vary from section to section? Explain.

Friction in Automobile Tires

Friction is a force that acts to oppose motion between two surfaces in contact with each other. This force is caused by the interaction of the two surfaces. This interaction is the result of a force called the normal force. A normal force pushes the two surfaces together. The greater the normal force, the greater the frictional force.

For a given normal force, different surface textures will produce differing amounts of frictional force. The coefficient of friction relates to the amount of frictional force produced per unit of normal force This is shown in the equation below.

$$\mu = \frac{F_f}{N}$$

In the equation above, μ is the coefficient of friction, F_f is the force of friction, and N is the normal force. In general, rough surfaces have higher coefficients of friction than smooth surfaces.

In this lab we will be finding the coefficient of friction for different tire treads and be looking at how a lubricant on the road would affect the coefficient of friction.

Equipment

Tire tread samples
25 kg. Spring scale
Weight set

Procedure

1. Obtain tread sample from teacher.
2. Measure the mass of the tread sample using spring scale and record in Data Table 1.
3. Place tread sample on ground, attach spring scale to pulling string.
4. Place 5 kg. Of mass on tread sample. Record in Data Table 1.
5. Pull tread sample horizontally across ground and read force needed to pull tread. You must pull at a constant speed in order to get a consistent reading. This force is the force of sliding friction and must be read while the tread is moving. Record in Data Table 1 as Friction Force.

6. Return tread sample to teacher and obtain another sample until steps 2-5 have been completed for the rough, normal, and smooth treads.

7. Pick an area of pavement where you will continue experiment and wet the surface with water.

8. Repeat steps 2-6 on wet surface and record all data in Data Table 1.

Tread Sample	Mass of Tread Sample	Mass on Sample	Total Mass	Normal Force	Friction Force	coefficient of friction
Rough						
Normal						
Smooth						
Rough on Wet Surface						
Normal on Wet Surface						
Smooth on Wet Surface						

Calculations

1. Add the mass of the tread sample to mass placed on sample and record as total mass in Data Table 1.

2. Find the Normal Force by calculating the force (weight) of the total mass of the tread and mass placed on it.

$$\text{Normal Force (N)} = \text{Total Mass (kg)} \times 9.8\ \frac{\text{N}}{\text{kg}}$$

Record as Normal force in Data Table 1.

3. Find the coefficient of sliding friction for each trial using the equation below.

$$\mu = \frac{F_f}{N}$$

μ = coefficient of sliding friction
F_f = force of friction
N = normal force

Record results in Data Table 1.

Questions

1. Which tread had the highest coefficient of friction? Why?

2. Which tread had the lowest coefficient of friction? Why?

3. How did making the surface we change the coefficients of friction?

Physics-Technical Integration Project

This project will involve the integration of each students technical are to the material covered during the two years of Physics. Each student will be required to write a two page report detailing the relationship between their technical area and one subunit covered within this course. This report should show the application of the ideas in a particular subunit or should show how the ideas have led to developments directly affecting their technical area. The subunits that have been covered in the past two years include:

FORCE
- Mechanical
- Fluid
- Electrical
- Thermal

WORK
- Mechanical
- Fluid
- Electrical

RATE
- Mechanical
- Fluid
- Electrical
- Thermal

RESISTANCE
- Mechanical
- Fluid
- Electrical
- Thermal

ENERGY
- Mech. and Fluid 1
- Mech. and Fluid 2
- Electrical
- Thermal

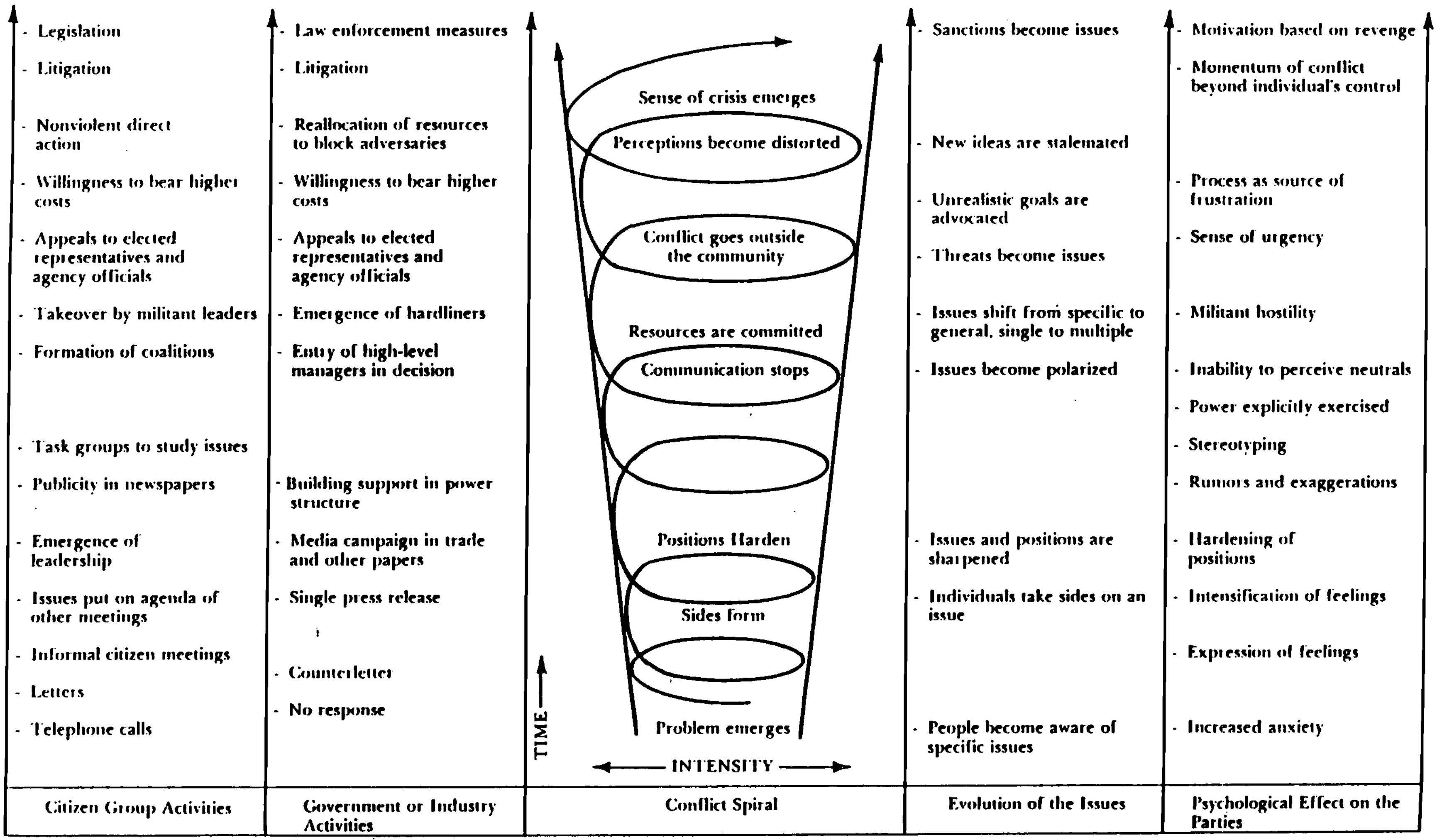
POWER
- Mechanical
- Fluid
- Electrical
- Thermal

FORCE TRANSFORMERS
- Mechanical Linear
- Mechanical Fluid
- Fluid
- Electrical

MOMENTUM
- Mech. and Fluid 1
- Mech. and Fluid 2

The second part of this project will involve a five minute presentation of your paper. During this presentation you should show the relationship between your technical area and Physics and demonstrate this with some type of visual aid.

Figure 1. Spiral of Unmanaged Conflict.



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