

# Teacher Package

## Science Exemplar Task Grade 9 Science – Academic Teacher Package

**Title:** A Check on the Density of Maple Syrup

**Time Requirement:** 2–3 classroom periods of 60 minutes each

### Description of the Task\*

The following scenario and instructions are to be provided for students.

#### A Check on the Density of Maple Syrup

Maple syrup is prepared by evaporating most of the water from sap collected from maple trees. Government regulations require that the minimum density of a product be 1.1 g/mL, indicating a specific sugar concentration, in order to be labelled as “Genuine Maple Syrup”.

Quality control technicians at Confederation Maple Syrup Co. do qualitative checks each hour on the syrup being produced. They test to see if the density meets the minimum government requirements. They have a standard solution of the minimum density that is coloured “yellow” with food colouring.

#### A. Hourly Qualitative Check

Samples from different evaporators in the factory are given identifying colours. Today, samples of unknown density from three different evaporators have just arrived. The samples are coloured to identify their source. These samples are coloured “red”, “blue”, and “green”. You, as a technician, are going to do a simple qualitative test to see if the unknowns have a density greater than, equal to, or less than the standard solution.

#### B. Daily Quantitative Check

Each day the technicians also do a quantitative check on the company product. You will also be doing this test.

#### C. Tours

Several times a month, school groups tour the Confederation Maple Syrup Co. Since density is a topic in Grade 5 science, these classes often stop at the quality control labs. You will be asked to make a presentation to them in Question 8.

\*This task has been adapted from Unit 1, Activity 3: “Properties of Water Density”, in the course profile for Science, Grade 9, Academic (Public).

### Final Product

- Completed student booklet

### Assessment and Evaluation

- The entire student booklet, which contains the student’s written answers, will be submitted for assessment. It will be scored using the task rubric.\*
- Laboratory skills, working collaboratively, and laboratory safety can be assessed by teacher observation.

### Expectations Addressed in the Exemplar Task

Students will:

1. solve density problems – given any two of mass, volume, and density, determine the third – using the formula  $density = mass/volume$  and appropriate SI units;
2. demonstrate the skills required to plan and conduct an inquiry into the properties of elements and compounds, using instruments, tools, and apparatus safely, accurately, and effectively;
3. gather and record qualitative and quantitative data using an appropriate format, and analyse the data to explain how the evidence gathered supports or refutes an initial hypothesis;
4. communicate scientific ideas, procedures, results, and conclusions using appropriate SI units, language, and formats, and evaluate the processes used in planning, problem solving, decision making, and completing the task;
5. investigate potential careers associated with an understanding of the physical and chemical properties of elements and compounds.

### Teacher Instructions

#### Prior Knowledge and Skills Required

- The expectations being assessed come from the strand Chemistry: Atoms and Elements and focus on density. For many classes, this task will serve as a review of expectations addressed earlier in the year.
- *The Ontario Curriculum, Grades 1–8: Science and Technology, 1998* addresses both solutions and density. Any deficits in the background from Grades 8 and 9 should be identified and reviewed as necessary.
- To complete this task, students should have some knowledge or skills relating to the following:
  - the concepts of density and of variables
  - collecting, recording, and interpreting data
  - distinguishing between qualitative and quantitative measurements
  - measuring with a balance and a graduated cylinder, transferring liquids with an eyedropper, and recognizing the degree of accuracy possible in reading scales and menisci
  - applying the mathematical formula  $D = m/V$  and using it to calculate density
  - the relationship between density and floating or sinking
  - the production of maple syrup
  - the economic costs involved in the production of a product

\*The rubric is reproduced on page 14 of this document.

**SI Metric Style**

- You should model good metric style for students. A resource is *Science: Intermediate/Senior Divisions (1987): Part 1, Program Outline and Policy*, Appendix B: Physical Quantities, and Appendix C: Metric Editorial Practice, pp. 79–98.
- The accepted symbol for density is  $\rho$  and an italic  $m$  and  $V$  are the symbols for mass and volume, respectively. Since some Canadian texts use  $D = m/V$ , either designation will be accepted for this task.

**Accommodations**

Accommodations that are normally provided in the regular classroom for students with special needs should be provided in the administration of this performance task.

You may wish to review the relevant course profile for specific suggestions for accommodations appropriate for students in special education programs.

**Working in Pairs and Individually**

- Students can work individually for the entire task, or if equipment and space limitations require it, they can work in pairs in the laboratory to conduct qualitative comparisons of solutions. The quantitative density measurement of the “unknown” solution should be carried out individually.
- After collecting laboratory data, students are to complete their reports individually, so that they may be assigned individual scores.

**Materials and Resources Required per Student or Student Pair**

- 4 test tubes (to hold samples)
- 12 test tubes, small diameter (to mix samples)
- 4 eyedroppers
- pencil/paper/ruler
- waste bucket
- paper towels
- beaker or test tube rack (to hold test tubes)
- 4 different coloured sugar solutions [described below](#)
- balance (minimum of one per four students)
- graduated cylinder (25 mL)

**Preparation**

- Show a bottle of maple syrup for any students who may not know what it is. The term “genuine” has been used instead of “pure” to avoid confusion with “pure substance”.

*Preparation of Solutions*

- Prepare the solutions, using warm water to speed the dissolving of the sugar.
- Each class requires a minimum of 500 mL of each of the solutions and twice this volume of solution #2.
- For students who have difficulty with colour, the solutions should be labelled as *Solution #1, Blue*, etc. The colour designations could also be shown on the chalkboard.

Solutions	
#1	Blue
#2	Red
#3	Green
Standard	Yellow

- If prepared as directed, the standard solution (yellow) has a density of 1.1 g/mL. The red solution also has a density of 1.1 g/mL. The blue solution has a density of 1.2 g/mL and the green solution has a density of 1.0 g/mL.
- Prepare four different solutions of the following densities:
  - > 150 g of sugar in 500 mL of water with blue food colouring (*solution 1, blue*)
  - > 150 g of sugar in 1.0 L of water, to be **divided into two 1 L samples**:
    - one with yellow food colouring (*standard solution, yellow*)
    - one with red food colouring (*solution 2, red*)
  - > 500 mL of tap or distilled water with green food colouring (*solution 3, green*)
- You may want to make solutions more extreme so that students find a larger quantitative difference (i.e., make the blue solution more concentrated).

*Test the Solutions and Procedure Before Administering the Task*

Perform the task in advance of the day of administration to become familiar with the observations and to verify densities. Determine the amount of food colouring required for best visibility on mixing. If the solutions are too dark, it will not be possible to see mixing of colours.

**Rubric**

Introduce the task-specific rubric to the students at least one day prior to the administration of the task. Review the rubric with the students and ensure that each student understands the criteria and the descriptions for achievement at each level.

Allow ample class time for a thorough reading and discussion of the assessment criteria outlined in the rubric.

Some students may perform below level 1. It will be important to note the characteristics of their work in relation to the criteria in the assessment rubric and to provide feedback to help them improve.

**Student Tasks and Proposed Answers**

**Procedure A for Hourly Testing** involves using an eyedropper to transfer twenty-five drops of solution 1 to a small-diameter test tube (10–12 mm in diameter). Students then slowly and carefully add three or more drops, if required, of solution 2, waiting ten seconds between drops. The drops should be allowed to run down the side of the test tube to maximize the effect. If the two solutions mix, then solution 2 has a density equal to or greater than the density of solution 1. If the three drops of solution 2 form a narrow ring above solution 1, then solution 1 is more dense than solution 2.

**Note:** Column 4 is requested in the instructions. **Do not** remind the students to include column 4 or that one of the options is  $X = Y$ . All you can do is remind them to read the instructions carefully.

**Proposed Answers (Questions 2, 3, 4)**

Solution in Tube	Solution Added on Top	Result	Meaning/Conclusion
Yellow	Blue	Blue sinks	$B > Y$
Blue	Yellow	Yellow floats or coloured ring forms	$Y < B$
Yellow	Green	Green floats or coloured ring forms	$G < Y$
Green	Yellow	Yellow sinks	$Y > G$
Yellow	Red	Mixes	$R > Y$ or $R = Y$
Red	Yellow	Mixes	$Y > R$ or $Y = R$
Blue	Red	Red floats or coloured ring forms	$R < B$
Red	Blue	Blue sinks	$B > R$
Blue	Green	Green floats or coloured ring forms	$G < B$
Green	Blue	Blue sinks	$B > G$
Red	Green	Green floats or coloured ring forms	$G < R$
Green	Red	Red sinks	$R > G$

**Qualitative Hourly Check**

The student should state that:

- blue is more dense than yellow (the standard) or  $B > Y$  or  $Y < B$ ;
- green is less dense than yellow (the standard) or  $Y > G$  or  $G < Y$ ;
- blue is the most dense liquid;
- green is the least dense liquid;
- yellow and red are equal in density or  $Y = R$ .

**Why Is There a Need to Control Sugar Concentration? (Question 5)**

- Students should indicate that a density below government regulation will not allow Confederation Maple Syrup Co. to label and sell the product as "Genuine Maple Syrup".
- Factors influencing Confederation to keep the density no greater than 1.1 g/mL could include its having to spend extra money, energy, and time, as well as use extra raw product, in evaporating off extra water to make a more concentrated sugar solution.

**Procedure B for Daily Test (Questions 6, 7)**

- Students take the sample that they have identified as equal in density to the standard and use the balance and graduated cylinder to gather the data necessary to calculate the density of the sample.
- Students make measurements and record them in neat format or in a labelled chart.
- Calculations are to show all steps and include units.

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Example:

mass of empty graduate = 53.65 g  
 mass of liquid + graduate = 65.20 g  
 mass of liquid = (65.20 - 53.65) g = 11.55 g  
 volume of liquid = 10.50 mL

$$D = m/V$$

$$D = 11.55 \text{ g} / 10.50 \text{ mL}$$

$$= 1.10 \text{ g/mL}$$

If prepared as directed, the standard solution (yellow) should have a density of 1.10 g/mL or 1.1 g/mL. The red solution should also have a density of 1.10 g/mL or 1.1 g/mL. The blue solution should have a density of 1.2 g/mL and the green solution a density of 1.0 g/mL.

**Procedure C for Explaining to Grade 5 Students on Tour (Question 8a)**

- Students describe the steps required to determine the mass of a measured volume of solution. They should find the mass of the empty graduated cylinder. They should measure out a certain volume of liquid and determine its mass by subtracting the mass of the graduated cylinder from the mass of the liquid and graduated cylinder. Mass divided by volume provides the mass per unit volume or the density.
- Since this explanation is to a touring Grade 5 class, appropriate language, clarity, completeness, and a logical sequence are required.

**Skills Necessary for Technician (Question 8b)**

- Student should indicate the laboratory skills necessary to obtain an accurate result.
- Additional qualities such as communication, working with others, promptness, etc., are expected at levels 2-4. Since this explanation is to a touring Grade 5 class, appropriate language, clarity, completeness, and a logical sequence are required.

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