Temperature and Linear Equation Lesson Plan

This lesson plan is developed by Hacettepe University under the coordination of Dr. Selay Arkün Kocadere, within the framework of the project "STEAM-BOX: Courses, Tools, Resources for Teachers (2020-1-HU01-KA201-078743)" funded by the Erasmus+ program of the European Union. The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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Integration

21st Century Theme: Environmental Literacy

Disciplinary Concepts	**Mathematics** Linear Equations	**Science Education** Heat and temperature
	Technology 3D drawing	**Art** -

Prerequisite Knowledge

Learning Outcomes for Mathematics

- Students are able to understand simple algebraic expressions and write them in different formats.
- Students are able to solve first-order equations with one unknown.
- Students are able to recognize the coordinate system with its properties, and show ordered pairs.
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Learning Outcomes for Science Education

- Students are able to make inferences based on the data they obtained from their experiments demonstrating that substances can change state with the effect of heat.
- Students are able to determine the melting, freezing and boiling points of pure substances, as a result of their experiments.
- Students are able to explain the basic differences between heat and temperature.
- Students are able to interpret the results by conducting experiments on heat exchange as a result of mixing liquids with different temperatures.
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Learning Outcomes for Information Technologies

- Students are able to visualize data using appropriate chart types.
- Students are able to create a table suitable for the purpose by recognizing the interface and features of the spreadsheet software.
- Students are able to divide a problem into sub-problems.
- Students are able to develop an original product for the solution of a specific problem.

Learning Outcomes

Grade Level: 8th-grade
Activity duration: 6 lesson hours

Learning Outcomes for Mathematics

- Students are able to express how one of the two variables that have a linear relationship changes depending on each other, via a table and an equation.
  In the representations shown with tables, the teacher uses expressions in ordered pairs.
  It is also emphasized how the value of one of the two variables changes according to the value of the other, and in this case, which one of the two variables is the dependent and which one is the independent variable.
- Students are able to create and interpret equations, tables and graphs of real-life situations with linear relationships.
  While analyzing the coordinate graph, the relationship between the x and y coordinates of the points on the line and the points at which they intersect the axes, whether they pass through the origin, and their parallelism to the axes are discussed.

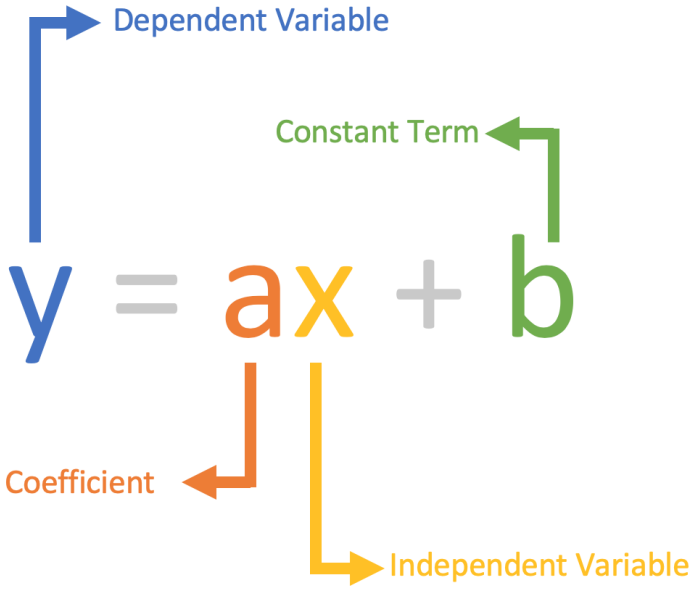
Learning Outcomes for Science Education

- Students are able to discover that the temperature change depends on the type, mass and/or heat of the substance.

	Learning Outcomes for Information technologies • Students are able to present the solution proposal and approach created for a determined problem. • Students are able to create model design. • Students are able to develop an original design product for a specific purpose.
Real World Context	**Problem Situation** As the weather gets colder, the consumption of hot drinks increases. However, it is very difficult to maintain the temperature of the drinks in cold weather. You are expected to create a product that will keep drinks hot for a long time in cold weather. The product you choose should both keep the temperature for a long time and be cost-effective and readily available.
	Materials Substances and Their Specific Heats Poster (Appendix 1), Experiment 1 (Appendix 2), Experiment 2 and Experiment 3 (Appendix 3), Let's Make Our Own Thermos (Appendix 4), Large glass container, balance scale, weight set, 3 Erlenmeyer flasks, 3 thermometers, 3 spirit stoves, 3 tripods, stopwatch, matches or lighters, tap water
	Preparation for the lesson Answers will be sought to the following questions: ● What is heat? What is temperature? What is the difference between heat and temperature? ● What are the variables that affect the temperature of a substance? ● What is a dependent variable? What is an independent variable? ● What is the relationship between the dependent and independent variable? How is this relationship represented with the help of equations and graphs? What is Tinkercad app? How to use it?
	Resources www.youtube.com https://www.eba.gov.tr/ https://www.freepik.com/ www.tinkercad.com
STEAM Activity	**Ask** The teacher starts the lesson with questions that will remind the information from their 5th grade curriculum and prepare them for the lesson. The teacher asks the students the following questions: ● What is heat? What is temperature? What is the difference between heat and temperature? ● In what cases does heat exchange occur? Can you give an example? ● What is specific heat? ● Where do we use specific heat in our daily lives? The teacher starts the video (Heat in Daily Life 8th grade) and helps the students discover the importance of specific heat.
	Research To explore the concepts of heat and temperature and to recognize the dependent and independent variables, the research phase of the lesson is carried out in the laboratory. Students are divided into groups of three or four. In order for the students to complete the experiments, they need to know the specific heats of the substances. For this reason, the poster named Substances and **Appendix 1. Their Specific Heats** should be hung on the board in a way that all students can see it easily. Each group is given a worksheet named **Appendix 2. Experiment 1**. The purpose of this experiment is to examine the effect of the type of substance on the temperature change. The groups are asked to complete the experiments and to fill in the questions on the worksheet during the experiment. Since flammable materials will be used during the experiment, it is important for teachers to guide the process carefully. At the end of the experiment, it is expected that the students realize that the temperature changes of the substances are different when heat is transferred and that the duration it takes to reach their initial temperature when the substances with the same final temperatures are left to cool is due to the type of the substance (specific heat). In this activity, the concepts of dependent variable and independent variable should be introduced to students. Groups are given worksheets named **Appendix 3. Experiment 2 and Experiment 3** . Experiment 2 and 3 are similar in terms of their implementation stages and materials. In Experiments 2 and Experiment 3, students are expected to discover that the temperature changes depending on the mass of the substance and depending on their initial temperature. The substances in Experiment 2 should be given to the students as a water-ice mixture with an initial temperature of 0 degrees. This is the only difference between Experiments 2 and 3. This difference provides the students for discovering the proportional relationship between the dependent and independent variable in the first

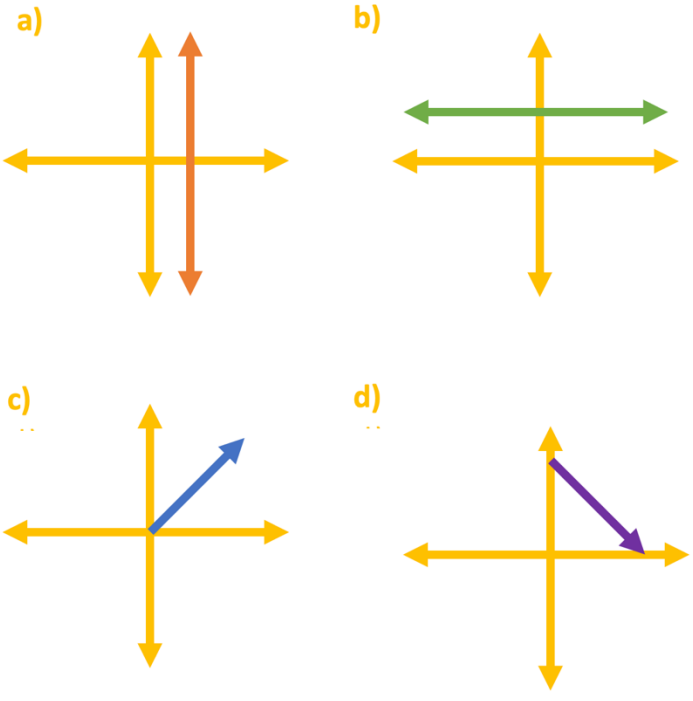
stage while creating an equation. The initial temperature of the substances given to the students in Experiment 3 must be different from 0 degrees. This will enable students to discover the constant term.

After the completion of the experiments, an equation is written on the board so that the students notice the names of the terms in the equation. Since this equation is expressed as a representation, the teacher should write it in a generalizable manner. Then the name of each term is introduced and students are asked to take notes. An example representation is provided below.



The following definition is shared with students.
The equations that can be written in the form of ax + by + c = 0, where a, b and c are real numbers and a ≠ 0 or b ≠ 0, are called linear equations. Depending on the values given to the x variable, the y variable takes different values.

The following linear graphs are shown to the students and a discussion environment is created in the classroom focusing on which situations these graphs can occur.



	The expected results of the students are as follows: a. The lines in the form of x = b are parallel to the y-axis, where b is a nonzero real number. In this expression, if b = 0, then x = 0, and this line indicates the y-axis. b. The lines in the form of y = a are parallel to the x-axis, where a is a non-zero real number. In this expression, if a = 0, then y = 0, and this line indicates the x-axis. c. It represents the situations in which the dependent variable increases as the independent variable increases. It represents the situations where the dependent variable decreases as the independent variable increases.
	Imagine The groups are given a worksheet named **Appendix 4 . "Let's Make Our Own Thermos"**. The teacher asks the students to make their own thermos. At this stage, there should be materials that should be available in the classroom. These materials should be the same as the materials used in the experiment phase. In order for the students to create their designs, the poster named Substances and **Appendix 1. Their Specific Heats** showing the specific heats of the substances that is going to be used is hung on the board so that the students can see it. It reminds students of the following information: *"The quantity of heat required to raise the temperature of a substance by 1 Celsius degree is called specific heat."*
	Plan Students are asked to determine the quantity of heat required to raise the temperature of the given materials and to model this in the Tinkercad application. The necessary steps for students and teachers who will use the Tinkercad application for the first time are as follows: a. Go to the application at https://www.Tinkercad.com/ . b. Open an account to log in to the Tinkercad application. c. After logging in, click on the button named "Designs" in the toolbar on the left. d. Click the "+New" button in the upper right corner of the page. e. Click on the section named "Circuit" from the drop-down list. f. After the design screen is opened, the materials to be used are as follows: LED, Resistor, Arduino, LCD 16x2, temperature sensor, Button g. Choose different colors of LED lights to represent each item (RGB LED can be preferred). 1. Connect the LED lights to the resistors and make the connections to the Arduino and Digital (PWM~) pins. 2. Connect a temperature sensor to each LED. 3. Add buttons to represent the different quantities of heat transferred. Each button must correspond to a temperature value (For example, when a button with a temperature value of 100 J is pressed, the temperature increases will be different depending on their specific heat.) 4. Observe the change in temperature increase of the items as the buttons are pressed. In this process, students are expected to discover that the quantity of heat required to raise the temperature of substances with a high specific heat must be high (in Tinkercad, one minute is equivalent to five joules. Therefore, when a button with 100 joules is pressed, the time it takes should be considered as 20 minutes).
	Create After discovering the temperature changes of different substances depending on the temperature increase, the students are asked to create a simulation showing the temperature change depending on the time elapsed when the substance they chose loses heat. Here, it is aimed to discover that a larger quantity of heat, and therefore more time should be given to increase the temperature of the substance with a large specific heat in the temperature increase of the materials.
	Test Students are asked to choose the material to be used in thermos construction with the results they obtained from the Tinkercad simulation. They are asked to draw a time-dependent graph of this item. The availability and cost-effectiveness of the selected item are tested.
	Improve Product selection after the testing phase, Appendix1 The worksheets are submitted to the teacher after making arrangements for the steps of creating graphs and equations.

Materials	The worksheet named **Experiment 1** will be used by the students to discover the specific heats of the substances, the dependent and independent variables during the research phase. The worksheets named **Experiment 2 and 3** will be used for students to create linear equations and to discover the terms of linear equations during the research phase. The worksheet named **Substances and Their Essences.png** will be hung in the classroom environment for all students to see so that students can use the specific heats of the substances they will use during the lesson plan. The worksheet named **Let's Make Our Own Thermos** will be given to the students at the imagine stage, and they will be asked to answer the questions about the steps they will follow during the planning, creating and testing stages of their own thermos.
Test	*This part will be completed by the teacher after the lesson plan is implemented in the classroom.*
Improve	*This part will be completed by the teacher after the lesson plan is implemented in the classroom. This activity was developed for secondary school level. The activity can be applied at the secondary education level by considering the parabola subject in mathematics lesson, and the endurance subject in the science lesson.*

Appendix 1. Substances and Their Specific Heats

Substance and Spesific Heat

Substance	Spesific Heat (J/g C)
Copper	0.37
Aluminium	0.90
Zinc	0.39
Lead	0.13
Nickel	0.45
Iron	0.46
Hydrargyrum	0.12
Alcohol	2.40
Water	4.18
Hydrogen	14.32

Appendix 2. Experiment 1

Necessary Materials: balance scales, weight set, water, olive oil, thermometer, 2 x 250 mL Erlenmeyer flasks, 2 tripods, 2 spirit stoves, stopwatch, lighter or matches.

Construction stages

- Weigh 100 g of water and 100 g of olive oil with a balance scale.
- Put the weighted water and olive oil into the Erlenmeyer flask.
- Measure the temperature of the liquids in the Erlenmeyer flask. Write the measurement results in the table below.
- Place the Erlenmeyer flask on the tripod. Light the identical spirit stoves that you put under the tripods at the same time.
- Heat the liquids in the Erlenmeyer flask for five minutes. Measure the final temperatures after five minutes. Record the measurement results in the table below.
- Calculate the temperature change in water and olive oil.

Answer the following questions based on the data you obtained during the experiment.

1) Write your hypothesis.

2) Fill in the blanks given in the table according to the data you obtained during the experiment.

Substances	Initial Temperature	Final Temperature	Temperature change
Water			
Olive oil			

3) Explain how the temperature changes of the substances to which you give the same quantity of heat differ. Explain your thoughts about the reasons for these changes.

4) Fill in the blanks in the sentences given below with appropriate words.

Water	**Dependent variable**	**Independent**	**Heat increase**
Independent variable	**Olive oil**	**Temperature increase**	**Dependent**

. As …….. changes ……. also varies.
. ……, ……. causes a change in the variable.
. ……, …… are variables that are observed to change in response to the variable.
. In this experiment …….. is the dependent variable
. In this experiment ……. is the independent variable.

5) Fill in the blanks given in the table according to the data you obtained during the experiment.

Substances	Final Temperature	Initial Temperature	Time Elapsed
Water			
Olive oil			

Water and olive oil, whose final temperatures are the same, are left to cool at room temperature.

6) Explain how the time to reach their initial temperature changes when substances with the same final temperatures are left to cool at room temperature. Please explain your thoughts on the reasons for this difference.

Appendix 3. Experiment 2

Necessary Materials: large glass container, balance scales, weight set, 3 Erlenmeyer flasks, 3 thermometers, 3 spirit stoves, 3 tripods, stopwatch, matches or lighters, tap water

Construction stages

- Fill the wide glass container with tap water.
- Measure 50g, 100g, 150g of water with the help of a balance scale, and pour it into the Erlenmeyer flask.
- Measure the temperature of the water in the Erlenmeyer flask with a thermometer, and record the measurement results in the table.
- Place the Erlenmeyer flask on the tripod. Light the identical spirit stoves that you put under the tripods at the same time.
- Measure the temperature of the liquids in the Erlenmeyer flask at two-minute intervals. Record the measurement results in the table below.

Answer the following questions based on the data you obtained during the experiment.

1) Write your hypothesis.

2) Record in the table after how many minutes the liquids in the Erlenmeyer flask start to boil.

The amount of water	**Initial temperature**	**The temperature of the water after 2 minutes**	**The temperature of the water after 4 minutes**	**The temperature of the water after 6 minutes**	**After how many minutes does the water start to boil?**
50g Water	0				
100g of Water	0				
150g Water	0				

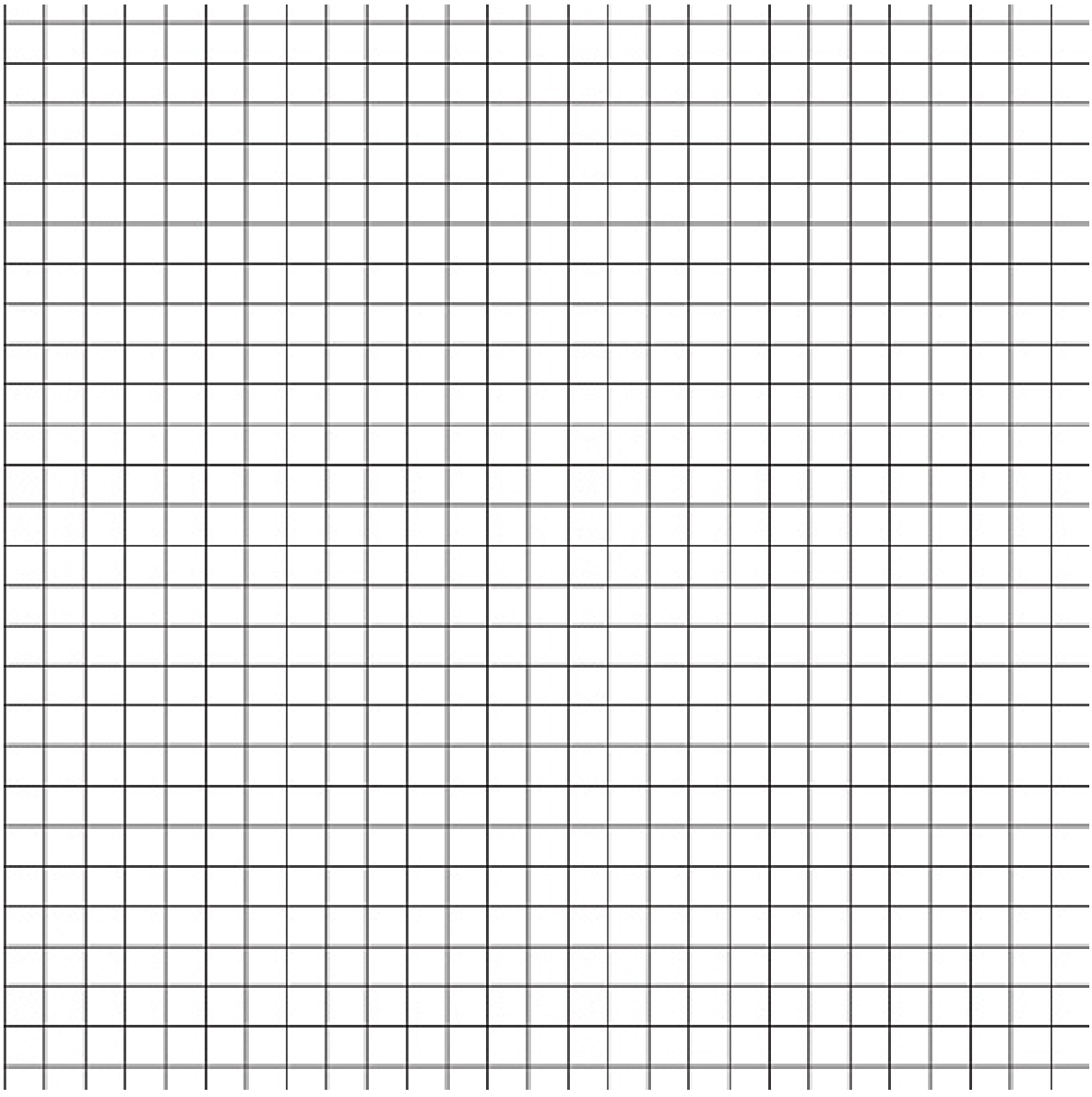
3) Determine the dependent and independent variable according to the table you filled in above.

Dependent variable:
Independent variable:

4) Write the dependent and independent variable in the table below. Write the changes of the dependent and independent variables using the table above.

Dependent variable ( )	**Independent variable ( )**

5) Graph the data of the dependent and independent variable.



6) Write an equation to find the temperature of the dependent variable at the desired time.

Experiment 3

Necessary Materials: large glass container, balance scales, weight set, 3 Erlenmeyer flasks, 3 thermometers, 3 spirit stoves, 3 tripods, stopwatch, matches or lighters, tap water

Construction stages

- Fill the wide glass container with tap water.
- Measure 50 g, 100 g, 150 g of water with the help of a balance scale, and pour it into the Erlenmeyer flask.
- Measure the temperature of the water in the Erlenmeyer flask with a thermometer, and record the measurement results in the table.
- Place the Erlenmeyer flask on the tripod. Light the identical spirit stoves that you put under the tripods at the same time.
- Measure the temperature of the liquids in the Erlenmeyer flask at two-minute intervals. Record the measurement results in the table below.

Answer the following questions based on the data you obtained during the experiment.

1) Write your hypothesis.

2) Record in the table after how many minutes the liquids in the Erlenmeyer flask start to boil.

The amount of water	**The temperature of the water after 2 minutes**	**The temperature of the water after 4 minutes**	**The temperature of the water after 6 minutes**	**After how many minutes does the water start to boil?**
50g Water				
100g of Water				
150g Water				

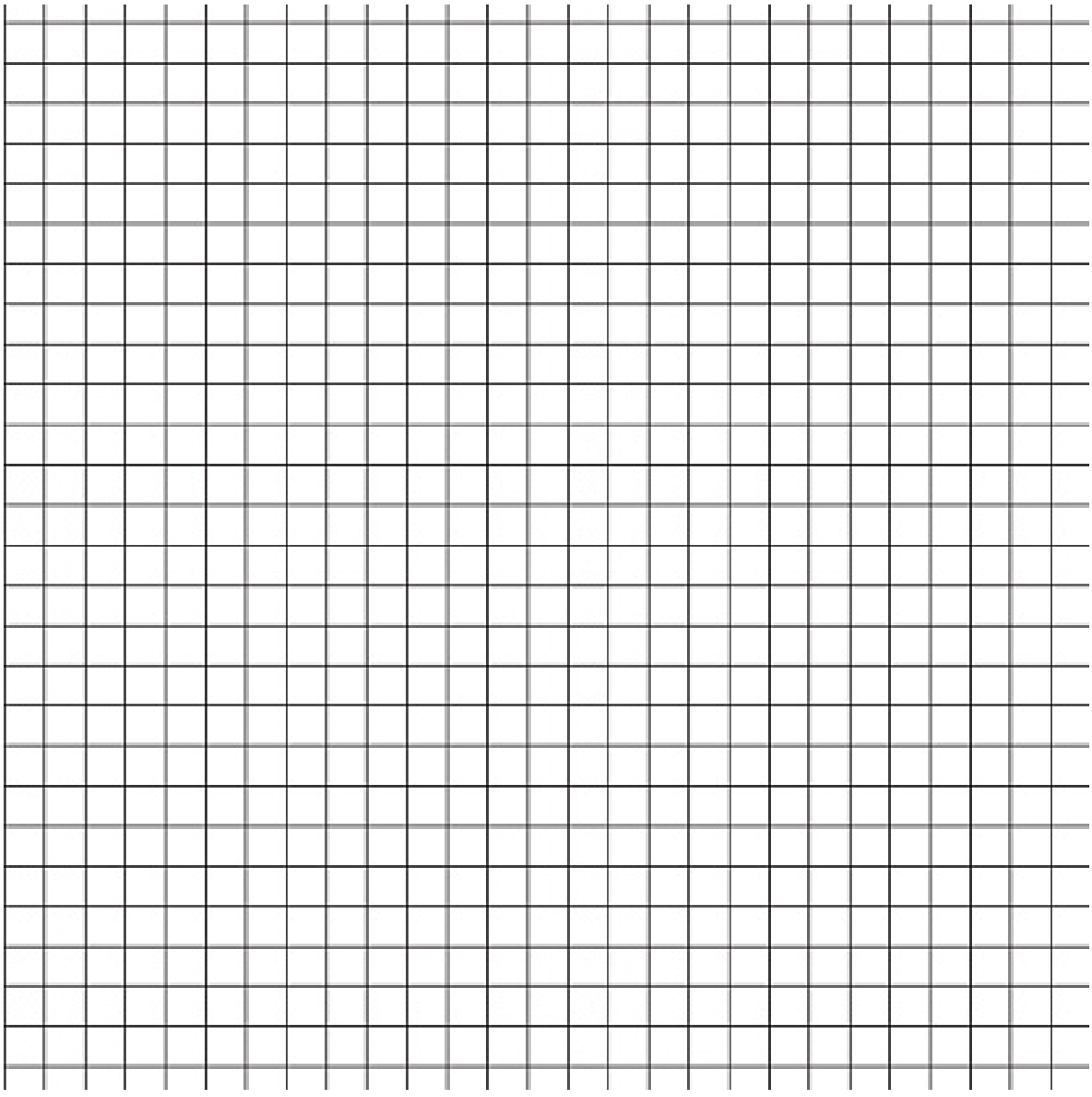
3) Determine the dependent and independent variable according to the table you filled above.

Dependent variable:
Independent variable:

4) Write the dependent and independent variable in the table below. Write the changes of the dependent and independent variables using the table above.

Dependent variable ( )	**Independent variable ( )**

5) Graph the data of the dependent and independent variable.



6) Write an equation to find the temperature of the dependent variable at the desired time.

Appendix 4. Let's Make Our Own Thermos

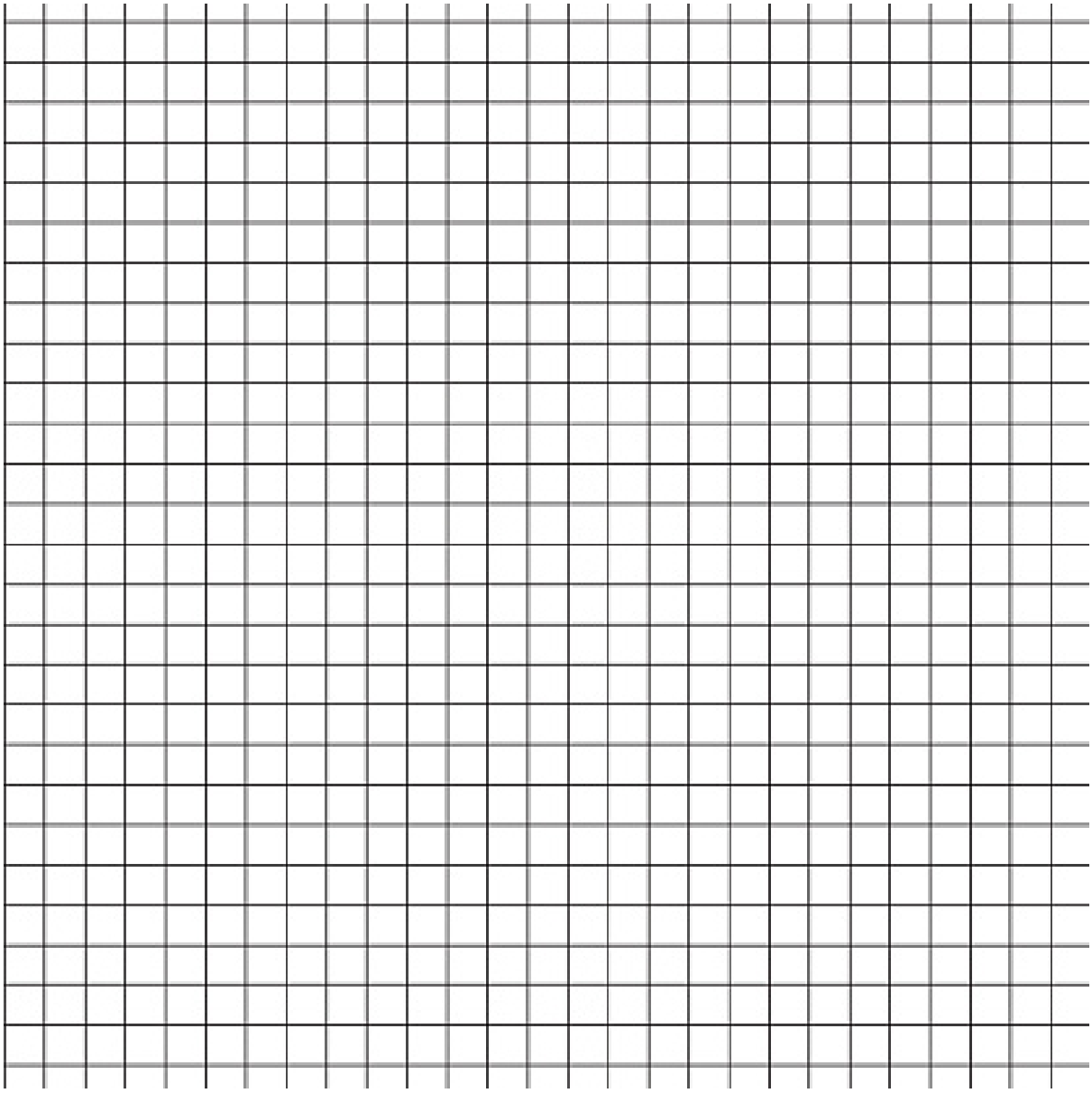
When the weather gets cold, an increase in thermos sales is observed. When purchasing a thermos, customers firstly pay attention to how long it keeps the liquids hot rather than the color, size, and shape of the thermos. The company you work for wants to design a thermos based on these requests of the customers. You are asked to calculate what material the thermos will be made of, and how long the liquids poured in the thermos will remain hot by choosing this material. The material you choose should be easy to find and cost-effective. In this context, answer the following questions.

1. **Elaborate on which material you chose for the thermos, and why you chose this material.**

2. **Using the Tinkercad simulation, fill in the table below using the time-varying temperature data.**

Temperature	Time

3. **Draw the temperature-time graph of the liquid(graph based on lost heat).**



4. **Write the temperature-time equation of the liquid. (graph based on lost heat)**