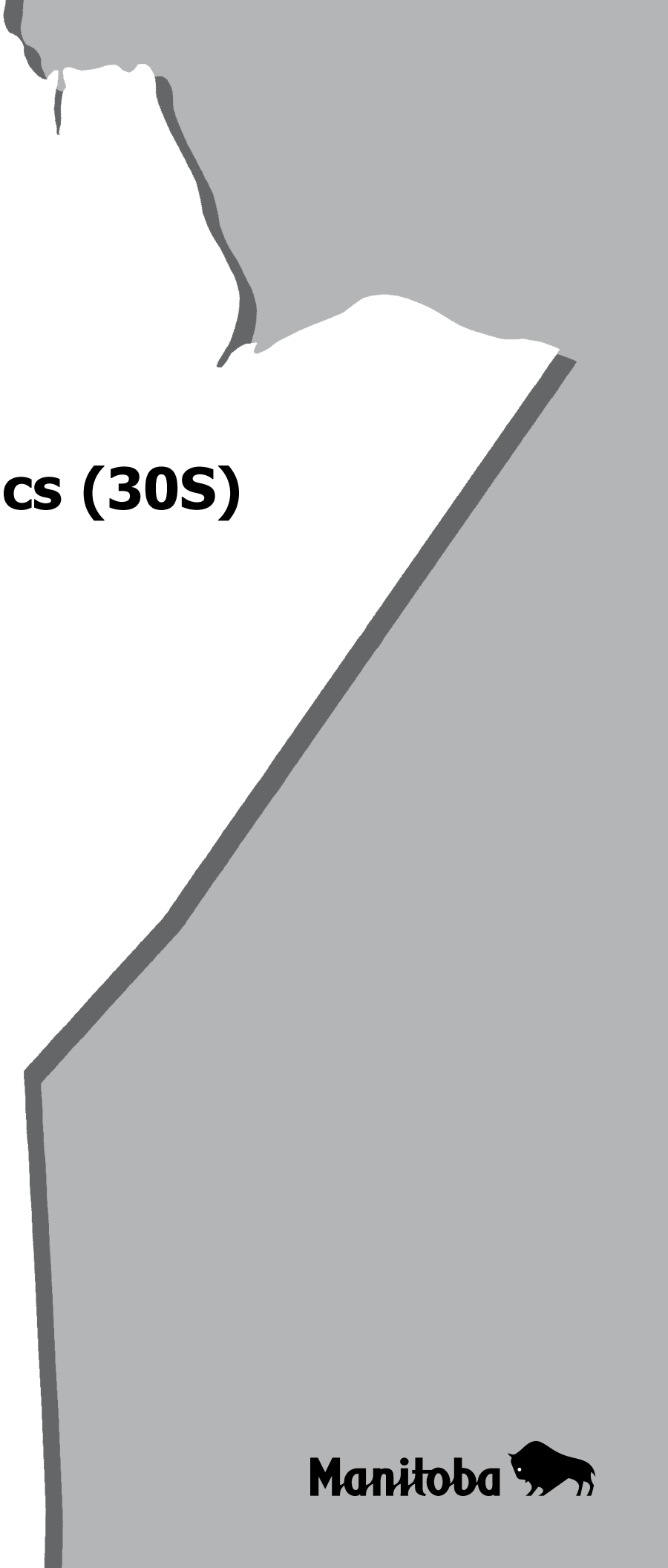
Grade 11 Physics (30S)

A Course for
Independent Study



Manitoba

GRADE 11 PHYSICS (30S)

A Course for Independent Study

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Introduction

INTRODUCTION

Overview

Welcome to Grade 11 Physics: A Course for Independent Study.

Grade 11 Physics deals with basic concepts that will form the foundation concepts necessary for you to study physics in the future. You have already studied many concepts in physics. For example, in Grade 9 Science you studied electricity. In Grade 10 Science you studied motion of vehicles and passengers, specifically how and why they move. We will be referring to concepts that you have studied in the past as the new concepts that you will be studying are introduced. In turn, the concepts that you learn in Grade 11 Physics will prepare you for Grade 12 Physics.

As a student enrolled in a distance learning course, you have taken on a dual role—that of a student and a teacher. As a student, you are responsible for mastering the lessons and completing the learning activities and assignments. As a teacher, you are responsible to check your work carefully, noting areas in which you need to improve and motivating yourself to succeed

What Will You Learn in This Course?

In this course, you will use scientific and technology-related knowledge to understand and interpret their environment. You will develop your mathematical, and analytical skills and demonstrate the application of the scientific method through viewing laboratory videos. Laboratory activities have an important role to play in any science course which reflects the nature of the discipline.

How Is This Course Organized?

The Grade 11 Physics course consists of four major topics. The four major topics are broken down into modules for a total of ten modules. The breakdown of topics and modules is shown below:

Topic 1: Mechanics

- Module 1: Kinematics
- Module 2: Vectors
- Module 3: Dynamics

Topic 2: Fields

- Module 4: Gravitational Fields
- Module 5: Electric Fields
- Module 6: Magnetic Fields and Electromagnetism

Topic 3: Waves

- Module 7: Waves in One Dimension
- Module 8: Waves in Two Dimensions

Topic 4: Sound and Light

- Module 9: Sound
- Module 10: Models, Laws, and Theories, and the Nature of Light

Each module in this course consists of several lessons, which contain the following components:

- **Lesson Focus:** The Lesson Focus at the beginning of each lesson identifies one or more specific learning outcomes (SLOs) that are addressed in the lesson. The SLOs identify the knowledge and skills you should have achieved by the end of the lesson. (For a complete list of the SLOs identified for Grade 11 Physics refer to Appendix D at the end of this course.)
- **Key Words:** This list identifies the important words that are used in the lesson. The key words are highlighted in bold within the text and identified by key word icons. They are defined in the Glossary at the end of the course in Appendix B.
- **Introduction:** The introduction sets the stage for the lesson. It may draw upon prior knowledge or briefly describe the organization of the lesson.
- **Lesson:** The main body of the lesson is made up of the content that you need to learn. It contains explanations, diagrams, and fully completed examples.
- **Learning Activities:** Most lessons include one or more learning activities that will help you learn about the lesson topics and prepare you for the assignments, the midterm examination, and the final examination. Once you complete a learning activity, check your responses against those provided in the Learning Activity Answer Key found at the end of the module. You will not submit the completed learning activities to your tutor/marker.
- **Assignments:** Assignments are found near the end of each module. You will mail or electronically submit all your completed assignments to your tutor/marker for assessment at the end of every module or every second module. In total, all assignments are worth 50 percent of your final course mark.

- **Video Files:** Some lessons refer to the *Grade 11 Physics (40S) Laboratory Activities* video files, which you are required to view for this course.
- **Summary:** Each lesson ends with a brief review of what you just learned.

This course also includes the following section:

- **Appendices:** At the end of the course, you will find four appendices, which contain information that is required for the course or that could be useful in helping you to complete the course. Here is a list of the appendices found a the end of the course:
  - **Appendix A: Equation Sheet** contains a list of equations grouped according to the topics addressed in this course. This list of equations will be provided with the exams that you will be writing. It is imperative that you learn which concept each equation refers to, the quantity associated with each symbol, and its unit of measurement.
  - **Appendix B: Glossary** defines terms used within this course..
  - **Appendix C: Kinematics Graphs Transformation Organizer**
  - **Appendix D: List of Specific Learning Outcomes** contains the complete list of SLOs to be achieved in Grade 11 Physics. You will not be using this appendix. It has been placed here to help classroom teachers who are using this course as a resource.

What Resources Will You Need for This Course?

You do not need a textbook for this course. All the content is provided directly within the course. You will, however, need access to a variety of resources.

The required resources for this course are identified below.

Required Resources

For this course, you will need access to the following resources. If you do not have access to one or more of these resources, contact your tutor/marker.

- **A calculator:** Use a graphing or scientific calculator as you work through this course. You will also need the calculator for the examination(s).
- **Equipment to view video files:** You will need equipment to view the *Grade 11 Physics (30S) Laboratory Activities* video files.

Electronic Resources

For this course, you will need the following electronic resource. If you do not have access to the Internet, or if you need a copy of the resource, contact the Independent Study Option (ISO) office at 1-800-465-9915.

- **Video(s):** You will have an opportunity to view the *Grade 11 Physics (40S) Laboratory Activities* video files, which are available in the Audios and Videos section of the distance learning website at <www.edu.gov.mb.ca/k12/dl/iso/av.html>. If you do not have access to the Internet or if you need a copy of the video, contact the ISO office at 1-800-465-9915.

Optional Resources

It would be helpful if you had access to the following resources:

- **Photocopier/scanner:** With access to a photocopier/scanner, you could make a copy of your assignments before submitting them so that if your tutor/marker wants to discuss an assignment with you over the phone, each of you will have a copy. It would also allow you to continue studying or to complete further lessons while your original work is with the tutor/marker. Photocopying or scanning your assignments will also ensure that you keep a copy in case the originals are lost.
- **Resource people:** Access to local resource people, such as teachers, school counsellors, and librarians, would help you complete the course.
- **A computer with spreadsheet software:** Access to spreadsheet software (e.g., Microsoft Excel) would help you to present and analyze data graphically.
- **A computer with Graphical Analysis software:** This software will help you to produce and analyze graphs. If you do not have access to this software and you are attending school, ask your ISO school facilitator how you can obtain access. If you are not attending school, you will have received the software with the course.

- **A computer with Internet access:** Some lessons suggest website links as sources of information or for supplementary reference and reading. If you do not have Internet access, you will still be able to complete the course, but you will need to find different ways of accessing information.

Who Can Help You with This Course?

Taking an independent study course is different from taking a course in a classroom. Instead of relying on the teacher to tell you to complete a learning activity or an assignment, you must tell yourself to be responsible for your learning and for meeting deadlines. There are, however, two people who can help you be successful in this course: your tutor/marker and your learning partner.

Your Tutor/Marker

Tutor/markers are experienced educators who tutor Independent Study Option (ISO) students and mark assignments and examinations. When you are having difficulty with something in this course, contact your tutor/marker, who is there to help you. Your tutor/marker's name and contact information were sent to you with this course. You can also obtain this information in the Who Is My Tutor/Marker? section of the distance learning website at <www.edu.gov.mb.ca/k12/dl/iso/assistance.html>.

Your Learning Partner

A learning partner is someone **you choose** who will help you learn. It may be someone who knows something about physics, but it doesn't have to be. A learning partner could be someone else who is taking this course, a teacher, a parent or guardian, a sibling, a friend, or anybody else who can help you. Most importantly, a learning partner should be someone with whom you feel comfortable and who will support you as you work through this course.

Your learning partner can help you keep on schedule with your coursework, read the course with you, check your work, look at and respond to your learning activities, or help you make sense of assignments. You may even study for your examination(s) with your learning partner. If you and your learning partner are taking the same course, however, your assignment work should not be identical.

How Will You Know How Well You Are Learning?

You will know how well you are learning in this course by how well you complete the learning activities, assignments, and examinations.

Learning Activities

The learning activities in this course will help you to review and practise what you have learned in the lessons. You will not submit the completed learning activities to your tutor/marker. Instead, you will complete the learning activities and compare your responses to those provided in the Learning Activity Answer Key found at the end of each module.

Make sure you complete the learning activities. Doing so will not only help you to practise what you have learned, but will also prepare you to complete your assignments and the examinations successfully. Many of the questions on the examinations will be similar to the questions in the learning activities. Remember that you **will not submit learning activities to your tutor/marker**.

Assignments

Each module in this course contains assignments, which you will complete and submit to your tutor/marker for assessment. The assignments are worth a total of 50 percent of your final course mark.

For some assignments, you will need to view the video *Grade 12 Physics (30S) Laboratory Activities*, gather data from the video, and write a laboratory report.

The video contains the following laboratory activities:

- *Kinematics*
- *Dynamics*
- *The Tangent Galvanometer*
- *The Magnetic Field of a Solenoid (Current Balance)*
- *Snell's Law*
- *Resonance and the Speed of Sound*
- *The Particle Model of Light*

You will submit the laboratory reports, along with the other assignments, to your tutor/marker for assessment.

The tutor/marker will mark your assignments and return them to you. Remember to keep all marked assignments until you have finished the course so that you can use them to study for your examinations.

Midterm and Final Examinations

The course contains a midterm examination and a final examination.

- The **midterm examination** is based on Modules 1 to 6 and is worth 20 percent of the final mark for the course. You will write the midterm examination when you have completed Module 6.
- The **final examination** is based on Modules 1 to 10, and is worth 30 percent of your final mark in this course. Most of the final exam (25% of your final mark) is based on Modules 7 to 10. A small portion of it (5% or your final mark) is based on Modules 1 to 6. You will write the final examination when you have completed Module 10.

The two examinations are worth a total of 50 percent of your final course mark. You will write both examinations under supervision.

To do well on each examination, you should review all the work you have completed from the modules, including all learning activities and assignments.

Practice Examinations and Answer Keys

To help you succeed in your examinations, you will have an opportunity to complete a Midterm Practice Examination and a Final Practice Examination. These examinations, along with the answer keys, are found in the Student Downloads section of the distance learning website at <www.edu.gov.mb.ca/k12/dl/downloads/index.html>. If you do not have access to the Internet, contact the Independent Study Option office at 1-800-465-9915 to obtain a copy of the practice examinations.

These practice examinations are similar to the actual examinations you will be writing. The answer keys enable you to check your answers. This will give you the confidence you need to do well on your examinations.

Requesting Your Examinations

You are responsible for making arrangements to have the examinations sent to your proctor from the ISO office. Please make arrangements before you finish Module 5 to write the midterm examination. Likewise, you should begin arranging for your final examination before you finish Module 10.

To write your examinations, you need to make the following arrangements:

- **If you are attending school,** ask your school's Independent Study Option (ISO) school facilitator to request your examination. Do this at least **three weeks before** you are ready to write your examination. For more information on examination procedures, please contact your ISO school facilitator or visit the Grading and Evaluation section of the distance learning website at <www.edu.gov.mb.ca/k12/dl/iso/assignments.html>.
- **If you are not attending school,** check the **Examination Request Form** for options available to you. The form was mailed to you with this course. **Three weeks before** you are ready to write your exam, fill in the Examination Request Form and mail, fax, or email it to

  ISO Office
  555 Main Street
  Winkler MB R6W 1C4
  Fax: 204-325-1719
  Toll-Free Telephone: 1-800-465-9915
  Email: distance.learning@gov.mb.ca

How Much Time Will You Need to Complete This Course?

Learning through independent study has several advantages over learning in the classroom. You are in charge of how you learn and you can choose how quickly you will complete the course. You can read as many lessons as you wish in a single session. You do not have to wait for your teacher or classmates.

From the date of your registration, you have a maximum of **12 months** to complete this course, but the pace at which you proceed is up to you. Read the following suggestions on how to pace yourself.

Chart A: Semester 1

If you want to start this course in September and complete it in January, you can follow the timeline suggested below.

Module	Completion Date
Module 1	Middle of September
Module 2	End of September
Modules 3 and 4	Middle of October
Modules 5 and 6	Middle of November
Midterm Examination	End of November
Modules 7 and 8	Middle of December
Modules 9 and 10	Beginning of January
Final Examination	Middle of January

Chart B: Semester 2

If you want to start this course in January and complete it in June, you can follow the timeline suggested below.

Module	Completion Date
Module 1	Middle of February
Module 2	End of February
Modules 3 and 4	Beginning of March
Modules 5 and 6	Beginning of April
Midterm Examination	Middle of April
Modules 7 and 8	Beginning of May
Modules 9 and 10	Middle of May
Final Examination	End of May

Chart C: Full School Year (Not Semestered)

If you want to start this course in January and complete it in June, you can follow the timeline suggested below.

Module	Completion Date
Module 1	End of September
Module 2	End of October
Modules 3 and 4	Middle of December
Modules 5 and 6	Beginning of February
Midterm Examination	Middle of February
Modules 7 and 8	End of March
Modules 9 and 10	Middle of May
Final Examination	End of May

Timelines

Do not wait until the last minute to complete your work, since your tutor/marker may not be available to mark it immediately. It may take a few weeks for your tutor/marker to assess your work and return it to you or your school.

If you need this course to graduate this school year, remember to schedule and complete your final examination by **May 31**.

Why Is the Course so Large?

This course package includes all the things you would find in a regular face-to-face physics course taught in a classroom, such as the following:

- all the information that is normally found in a textbook
- all the notes that a teacher would hand out in class
- all the assignments that a teacher would hand out in class
- all the learning activities that a teacher would hand out in class, along with their answer keys
- all the explanations and instructions that a teacher would either say or write on a blackboard or whiteboard

This course also contains many diagrams and graphs, which tend to take up more room than straight text. This makes the course seem larger than it actually is.

When and How Will You Submit Completed Assignments?

When to Submit Assignments

While working on this course, you will submit completed assignments to your tutor/marker six times. Each time you submit assignments, you must include the applicable Cover Sheet, which you will find at the end of this Introduction.

The following chart shows exactly what assignments you will be submitting at the end of every module or every second module.

Submission of Assignments	
Submission	Assignments You Will Submit
1	**Module 1: Kinematics** Module 1 Cover Sheet Assignment 1.1: Part A: Symbolic Mode Part B: Significant Digits Part C: Scalars and Vectors Part D: Position-Time Graph 1 Assignment 1.2: Video Laboratory Activity: Kinematics Assignment 1.3: Part A: Acceleration-Time Graph Part B: Position-Time Graph 2 Part C: Constant Velocity and Acceleration
2	**Module 2: Vectors** Module 2 Cover Sheet Assignment 2.1: Part A: Drawing Vectors Part B: Sketching Vectors Part C: Adding Vectors Assignment 2.2: Vector Journey
3	**Module 3: Dynamics / Module 4: Gravitational Fields** Module 3/Module 4 Cover Sheet Assignment 3.1: Video Laboratory: Dynamics Part A: Free-Body Diagrams Part B: Dynamics and Kinematics Part C: The Vector Nature of Newton's Second Law Assignment 4.1: Part A: Gravitational Fields Part B: Mass, Weight, and Weightlessness Assignment 4.2: Laboratory Activity: Determining Acceleration Due to Gravity Assignment 4.3: Part A: Free Fall Part B: Friction

Submission of Assignments (continued)	
Submission	Assignments You Will Submit
4	**Module 5: Electric Fields / Module 6: Magnetic Fields and Electromagnetism** Module 5/Module 6 Cover Sheet Assignment 5.1: Electric Fields Assignment 5.2: Part A: Calculating Electric Field and Electric Force Part B: The Parallel Plate Apparatus Part C: The Millikan Drop Experiment Assignment 6.1: Part A: Magnetic Fields Part B: The Earth's Magnetic Field Part C: Electromagnetism Assignment 6.2: Video Laboratory Activity: The Tangent Galvanometer Assignment 6.3: Video Laboratory Activity: The Magnetic Field of a Solenoid (Current Balance) Assignment 6.4: Forces on Currents in a Magnetic Field
5	**Module 7: Waves in One Dimension / Module 7: Waves in Two Dimensions** Module 7/Module 8 Cover Sheet Assignment 7.1: Part A: Transverse Waves and Longitudinal Waves Part B: Reflection and Transmission of Waves in One Dimension Part C: Wave Interference and Standing Waves in One Dimension Part D: Resonant Frequency and Harmonics Assignment 8.1: Waves in Two Dimensions—Reflection Assignment 8.2: Video Laboratory Activity: Snell's Law Assignment 8.3: Part A: Waves in Two Dimensions—Refraction Part B: Waves in Two Dimensions—Diffraction Part C: Waves in Two Dimensions—Interference
6	**Module 9: Sound / Module 10: Models, Laws, and Theories, and the Nature of Light** Module 9/Module 10 Cover Sheet Assignment 9.1: Part A: The Nature of Sound Part B: Beats and Resonance Part C: The Doppler Effect Assignment 9.2: Video Laboratory Activity: Resonance and the Speed of Sound Assignment 9.3: Music and Noise Assignment 10.1: The Scientific Method, Laws, Theories, and Models Assignment 10.2: Video Laboratory Activity: The Particle Model of Light Assignment 10.3: Part A: The Nature of Light and Newton's Corpuscular Theory Part B: Determining the Speed of Light Part C: Wave Theory of Light Part D: Young's Experiment Assignment 10.4: The Photoelectric Effect and Wave-Particle Duality

How to Submit Assignments

In this course, you have the choice of submitting your assignments either by mail or electronically.

- **Mail:** Each time you **mail** something, you must include the print version of the applicable Cover Sheet (found at the end of this Introduction).
- **Electronic submission:** Each time you **submit** something electronically, you must include the electronic version of the applicable Cover Sheet (found in the Student Downloads section of the distance learning website at <www.edu.gov.mb.ca/k12/dl/downloads/index.html>) or you can scan the Cover Sheet located at the end of this Introduction.

Complete the information at the top of each Cover Sheet before submitting it along with your assignments.

Submitting Your Assignments by Mail

If you choose to mail your completed assignments, please photocopy/scan all the materials first so that you will have a copy of your work in case your package goes missing. You will need to place the applicable module Cover Sheet and assignments in an envelope, and address it to

ISO Tutor/Marker
555 Main Street
Winkler MB R6W 1C4

Your tutor/marker will mark your work and return it to you by mail.

Submitting Your Assignments Electronically

Assignment submission options vary by course. Sometimes assignments can be submitted electronically and sometimes they must be submitted by mail. Specific instructions on how to submit assignments were sent to you with this course. You can also obtain this information in the Grading and Evaluation section of the distance learning website at <www.edu.gov.mb.ca/k12/dl/iso/assignments.html>.

If you are submitting assignments electronically, make sure you have saved copies of them before you send them. That way, you can refer to your assignments when you discuss them with your tutor/marker. Also, if the original assignments are lost, you are able to resubmit them.

Your tutor/marker will mark your work and return it to you electronically.

The Independent Study Option office does not provide technical support for hardware-related issues. If troubleshooting is required, consult a professional computer technician.

What Are the Guide Graphics For?

Guide graphics appear in the margins of the course to identify specific tasks. Each graphic has a specific purpose, as described below:

Lesson Focus/Specific Learning Outcomes SLOs): Note that these SLOs will be addressed within the lesson. (A complete list of the Grade 11 Physics SLOs can be found in the Appendix at the end of this course.)

Internet: If you have access to the Internet, you can use it to get more information. Internet access is optional for this course.

Learning Partner: Ask your learning partner to help you with this task.

Tutor/Marker: Ask your tutor/marker for assistance with or clarification on any topic or material in this course.

Learning Activity: Complete a learning activity. This will help you to review or to practise what you have learned and prepare you for an assignment or an examination. You will not submit learning activities to your tutor/marker. Instead, you will compare your responses to those provided in the Learning Activity Answer Key found at the end of the applicable module.

Assignment: Complete an assignment. You will submit your completed assignments to your tutor/marker for assessment at the end of a given module.

Video: View a video.

Mail or Electronic Submission: Mail or electronically submit your completed assignments to your tutor/marker for assessment.

Examination: Write your midterm or final examination at this time.

Note: Take note of and remember this important information or reminder.

Remember: If you have questions or need help at any point during this course, contact your tutor/marker or ask your learning partner for help.

Good luck with this course!

Grade 11 Physics (30S)

Topic 1: Mechanics

TOPIC 1: MECHANICS

Introduction to Topic 1

The first topic in this course is mechanics which deals with the relationships between matter, force, and energy, especially as they affect the motion of objects. Mechanics is broken up into two parts—kinematics and dynamics.

In Module 1, you learn the principles of kinematics—a description of motion itself. Module 2 deals with vectors. Although vectors does not fall into either kinematics or dynamics, you need to understand vectors in order to study dynamics. Vectors are types of number that indicate not only magnitude (like all other numbers), but also direction. Module 3, the study of dynamics, explains why motion occurs the way it does. This involves an understanding of the forces that act on objects.

NOTES

GRADE 11 PHYSICS (30S)

Module 1: Kinematics

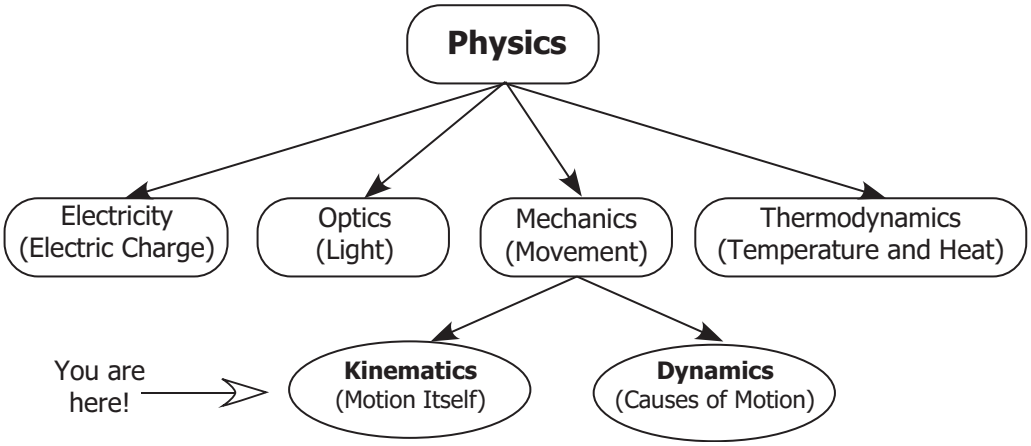
This module contains the following

- Introduction to Module 1
- Lesson 1: Introduction to Physics
- Lesson 2: Working with Vectors, Scalars, and Significant Figures
- Lesson 3: Terms for Describing Motion
- Lesson 4: The Position-Time Graph and Velocity
- Lesson 5: Analyzing Velocity-Time Graphs using Slope
- Lesson 6: Analyzing Motion Graphs using Area
- Lesson 7: Deriving Equations for Motion Involving Uniformly Accelerated Motion
- Lesson 8: Constant Velocity and Acceleration: Problem Solving
- Module 1 Summary

MODULE 1: KINEMATICS

Introduction to Module 1

Welcome to the first module of Grade 11 Physics. The first lesson of this module is an introduction to physics. In Lesson 2, you will be working with vectors, scalars, and significant figures. In the third lesson, you will learn about terms for describing motion. Lesson 4 deals with the position-time graph and velocity. In Lesson 5, you will analyze velocity-time graphs using slope. In Lesson 6, you will analyze motion graphs using area. In Lesson 7, you will derive equations for motion involving uniformly accelerated motion. The final lesson deals with solving problems dealing with constant velocity and acceleration.



Assignments

This table lists all the assignments you will have to complete in this module.

Lesson	Assignment Number	Assignment Title
1	Assignment 1.1, Part A	Symbolic Mode
2	Assignment 1.1, Part B	Significant Digits
3	Assignment 1.1, Part C	Scalars and Vectors
4	Assignment 1.1, Part D	Position-Time Graph 1
5	Assignment 1.2	Video Laboratory Activity: Kinematics
5	Assignment 1.3, Part A	Acceleration-Time Graph
6	Assignment 1.3, Part B	Position-Time Graph 2
7	There are no assignments in Lesson 7.	
8	Assignment 1.3, Part C	Constant Velocity and Acceleration

As you work through this course, remember that your learning partner and your tutor/marker are available to help you if you have questions or need assistance with any aspect of the course.

LESSON 1: INTRODUCTION TO PHYSICS (2 HOURS)

Learning Outcomes

When you have completed this lesson, you should be able to

- ❑ describe what physics is
- ❑ list and describe the four modes of representation
- ❑ describe a relationship among variables using the four modes of representation

Key Words

physics
graphical mode
independent variable
line of best fit
visual mode
symbolic mode
dependent variable
slope
numerical mode
variables
constant

Introduction

This first lesson will provide you with a description of the meaning of physics, which is not as easy as it might seem. This lesson will also examine the different ways that we look at things in physics. One way of describing things in physics is to use equations. Your understanding of the concepts of physics will come from analyzing a situation using a variety of methods that we call **modes of representation**. It is only through the process of looking at a situation from a variety of angles (or "modes") that a full understanding can be achieved. This course will employ a variety of these modes of representation.

What is Physics?

This question does not have a simple answer, or, rather, it has a simple answer but that answer by itself is not very helpful. If you look up physics in a dictionary or even in the back of a physics textbook, you will usually find an unhelpful statement, such as: "physics is the study of the properties and relationships between matter and energy." While this is not wrong, it doesn't really help you understand what it is. So to help understand what physics is, let's take a backwards approach.

In school, science is often divided into three main parts, or **disciplines**. They are physics, chemistry, and biology. Of the three, most people have at least a beginning understanding of biology—it is the "study of living things." Most people also know that chemistry concerns itself with "chemicals"—what they are made up of and how they interact with each other. While these descriptions of biology and chemistry are not very complete, they are at least a beginning. It is rare that people are able to provide even such a rudimentary definition of physics. So here is the *first* way that you can think of physics: physics is the *rest of science* after chemistry and biology have been accounted for.

You probably already know at least approximately what "science" is all about. For example, you are likely aware that the following things can be learned about in science and are therefore a part of science:

- The production of lightning and thunder
- The inner workings of the heart
- How rainbows are produced
- The rusting of certain metals
- Gravity
- How plants produce food
- The burning of gasoline

In this list, the item "inner workings of the heart" clearly involves life and is therefore best considered to be a part of biology, as is the item on "how plants produce food." The "rusting of certain metals" and the "burning of gasoline" involve the behaviours and interactions of different kinds of substances, and so are considered to be part of chemistry. All of the other items are physics!

It might seem silly identifying physics as "the rest of science," but historically this is pretty much how what we now call physics came to be.

The following points are summarized from the section "From Philosophy to Physics" in the book *The Search for Knowledge* by Isaac Asimov:

- In ancient times, there was no such thing as science, and certainly no physics, chemistry, or biology. Instead there were "philosophers" who were literally "lovers of wisdom."
- Some philosophers studied natural phenomena and were referred to as "natural philosophers," which is essentially what we would now think of as "scientists."
- The Greek word for "natural" is "physikos"—so physics was initially considered to be the same as "science."
- When people eventually specialized into specific areas of study, these areas were given their own names (mathematics, astronomy, geology, chemistry, and biology) and were removed from the topic of "physics."
- What we now call physics is what remains after the above have been removed.
- Splitting up science into separate areas is artificial, and in fact these areas tend to blend into each other.

Why Study Physics?

People are likely to give you different answers to this question because each might value different things. So here are several answers to this question in no particular order. Note that these are not necessarily *all* the answers!

1. Asking why one would study physics is like asking why one would learn how to draw, to play an instrument, or to play a sport. Sure, there *might* be a life-changing benefit (maybe you will get fabulously rich by becoming a famous artist/musician/athlete), but it is also perfectly acceptable to pursue these activities just for interest and fun. Many people actively doubt this about physics, preferring instead to think of physics as being very dull and certainly not something that could ever be "fun." Of course, some of these same people are fascinated to learn about such things as electricity, black holes, curve balls, and holograms—all of which involve physics. In other words, knowledge of physics helps to satisfy our natural curiosity about the world around us—everything from tsunamis to forensics.
2. Studying physics is necessary or, at least, strongly recommended for certain careers, such as engineers, medical doctors, dentists, pilots, meteorologists, and, of course, physicists.

3. Understanding physics can also be very practical, often when you least expect it. For example, understanding basic physics concepts can help you make more informed choices when buying many things (such as stereos, computers, and even cars), or how to get better mileage from your car.
4. A good foundation in physics can go a long way toward helping you understand other topics you may find interesting, such as chemistry, biology, computers, astronomy, geology, and music.

The Four Modes of Representation

If you consider the various branches of physics and the underlying principles, a common theme exists:

> Physics is the study of relationships in the world we perceive around us.

However, those relationships are embedded in a social and historical context—a set of lenses through which the relationships are perceived and acted upon. For example, we contemplate "something interesting," and then build models to identify fundamental characteristics to determine how they interact and influence each other. From these relationships, we are able to predict the behaviour of other "interesting things" that have the same or similar parameters. A major component of physics, then, is the study of relationships in a variety of different forms.

These different modes of representation are the different ways we look at a situation and the different ways we can represent the relationships within that situation. The more modes of representation we use, the better we will understand those relationships—that is, the physics that underlines that situation.

Mode Number 1: Visual

Have you ever been bored and played with an elastic band? You likely noticed that the more you pull, the more the band stretches. This is a simple experiment whose results can be expressed in words so that you get a picture in your mind of what is happening.

> Because it gives you a picture in your mind, it is an example of the **visual mode** of representation.

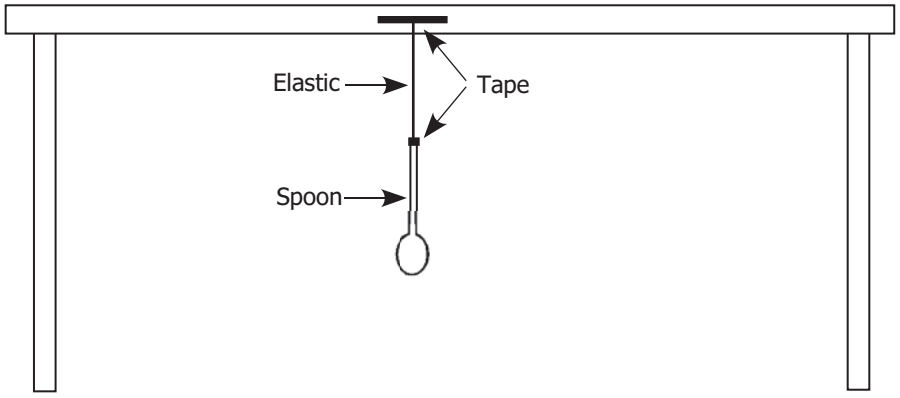
Sometimes this is also called a **qualitative** description because it describes the quality of the event. Qualities include things like pull and stretch.

For the remainder of this lesson, you will need the following things:

1. a thin elastic band cut once to make an elastic "string"
2. tape (transparent, masking, or duct will do)
3. a 30-cm ruler
4. five metal tablespoons.

Test your elastic string to be sure you can stretch it a bit and it will not break. Then tape one end to the edge of a table or counter so that the other end will hang over the edge and be a fair bit above the ground.

Visual Mode of Representation



Now we are ready to move on to the next mode.

Mode Number 2: Numerical

To get a more exact relationship between pull and stretch, we must collect data or numbers. This is called a quantitative description. In the **numerical** mode of representation, we must define the measurements and use equipment to collect the data.

> The **numerical mode** describes the relationship using numbers.

The data can then be examined to determine an exact relationship. There are basically three kinds of data:

1. **constants**—values that are the same during the experiment
2. **independent variables**—values that are set by the experimenter
3. **dependent variables**—values that are measured during the experiment

In our case, the elastic string is a constant. The number of tablespoons is the independent variable. The amount the elastic stretches will be the dependent variable.

Now that the string is taped to the edge of a table or countertop:

1. Place a piece of tape on the string about 10 cm down from the edge of the table.
2. Measure the exact length with the ruler and record it in the table below in the space with a (*).
3. Tape one spoon to the string so that the end of the handle is on the top edge of the piece of tape.
4. Let the spoon hang freely and measure the string length from the table edge to the tape mark (spoon handle top), and record this information in the table.
5. Tape another spoon on top of the first, just as they rest together inside a drawer.
6. Measure the length, record information in the table, and repeat until you have used all four spoons. Hopefully, the whole thing will not pull off the table before you are finished!

Number of Spoons	String Length (cm)	Stretch (cm)
0	(*)	0
1		
2		
3		
4		

Now calculate the amount the string stretched for each spoon added. You will do this by subtracting the original length, (*) amount, from each length. Consider the example below:

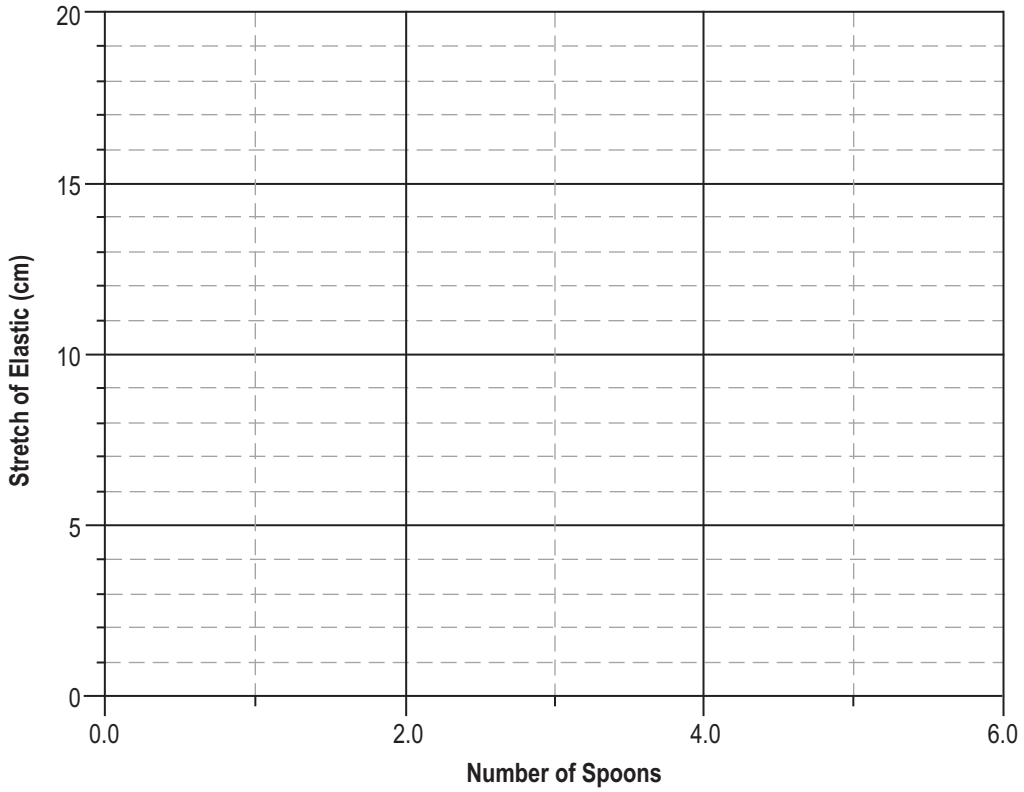
Number of Spoons	String Length (cm)	Stretch (cm)
0	(*) 9.7	0
1	12.0	2.3
2	14.2	4.5
3	16.6	6.9
4	18.9	9.2

Mode Number 3: Graphical

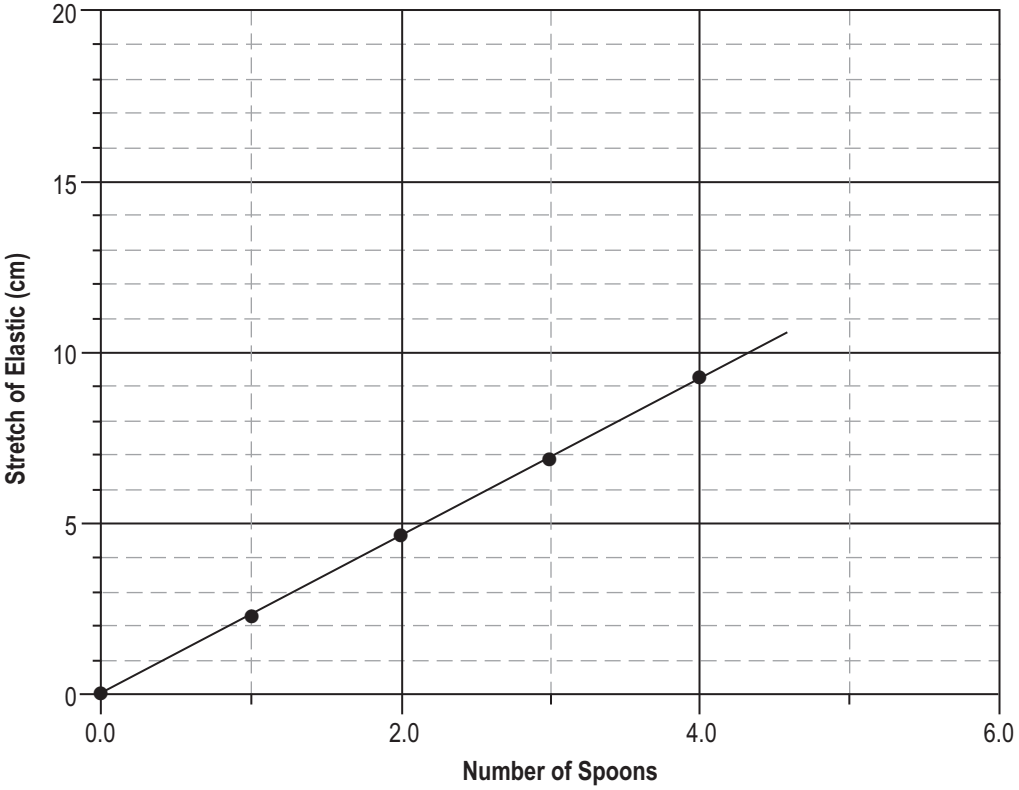
The **graphical mode** is a mathematical picture of the data.

For this graph, place the amount of stretch on the vertical axis and the number of spoons on the horizontal axis. When placing the numbers along the axes, start at zero and distribute the numbers evenly. After placing the data points on the graph, join them with a line of best fit. A **line of best fit** is a straight line through the data points so that it touches as many points as possible and has as many points above as below the line. Do not draw a line from one data point to the next. You may want to add a title to the graph.

Plot your data on the graph below.



Using the example data the graph would look like:



You learned in mathematics that the equation of a straight line can be written as $y = mx + b$ where m represents the slope of the line and b represents the y-intercept. In this case the y-intercept is zero since the graph begins at the origin. For this course, the y-intercept will remain at zero for the data we collect.

For the graph above, the y-values are the values of the stretch of the string. The x-values represent the number of spoons. In this case we could determine the value of the slope. The slope is determined by dividing the difference in the y-coordinates by the difference in x-coordinates for two points. Choose two data points that are on your line of best fit. If we use the coordinates (0,0) as (x_1, y_1) and (3,6.9) as (x_2, y_2), then the slope is

$$m = k = \frac{y_2 - y_1}{x_2 - x_1} = \frac{6.9 \text{ cm} - 0.0 \text{ cm}}{3.0 \text{ spoons} - 0.0 \text{ spoons}} = 2.3 \text{ cm/spoon}$$

Determine the slope of your graph.

$$m = k = \frac{y_2 - y_1}{x_2 - x_1} =$$

Mode Number 4: Symbolic

The **symbolic mode** represents the relationship as an algebraic equation/formula.

Generally, an algebraic equation is determined by using the graph. The purpose of the algebraic equation is to predict new situations that were not recorded in the experiment. For example, "How much will the string stretch with five spoons?" We can start by writing a word equation as:

Stretch of string = (slope of line) x (number of spoons)

Then we can introduce some algebraic symbols, such as:

S = stretch of string
n = number of spoons

Using the data from the example, the algebraic equation will then be:

$S = 2.3n$

If we had placed five spoons on the string, then we would predict the stretch to be:

$$\begin{aligned} S &= 2.3n \\ &= 2.3(5) \\ &= 11.5 \text{ cm} \end{aligned}$$

Determine the stretch of your string with five spoons and then test it by adding another spoon to your apparatus.

Note: The algebraic equations we will develop in this course have accepted symbols and are written in a traditional way. For the purpose of explaining the modes of representation, we have used arbitrary symbols and format for a well accepted law of nature. The law is called Hooke's Law and predicts how all elastic materials will behave when a force (push or pull) is applied to them. The accepted format for Hooke's Law is:

$F = kx$

Where F = the force applied, measure in Newtons
k = the spring constant (how stiff the spring is), measure in Newtons/metre
x = the stretch or compression of the spring, measured in metres

You do not need to understand Hooke's Law at this point. What you have to understand are two things:

1. There are four ways (modes) to express an event. All of the modes are important when dealing with physics. We do not want you to think of physics as simply plugging numbers into formulas and calculating an answer. You should be able to explain an event in any or all of the modes.
2. There are accepted ways of representing the algebraic equations we will come across in this course. Sometimes it may not seem to make sense why certain symbols are being used. Just remember that physics is an old science and tradition is important. Also, there are only so many symbols to choose from and many are used more than once in different contexts.

Learning Activity 1.1

Recording Data

Now you will get the chance to review and practice what you have learned by completing this learning activity. Remember, you do not submit learning activities for assessment. Instead, you complete them in order to prepare yourself to complete the assignments (which are submitted for assessment). Once you have completed this learning activity, check your answers in the answer key at the end of this module.

1. A person is moving slowly at a constant speed to the right. Every second, the distance travelled from the origin is recorded. The diagram below is one way to **visually** record the data. In this situation, the independent variable is the time.

   • At t = 0.0 s, the distance travelled d = 0.0 m.
   •⟶ At t = 2.0 s, d = 1.0 m
   •⟶ At t = 4.0 s, d = 2.0 m
   •⟶ At t = 6.0 s, d = 3.0 m
   •⟶ At t = 8.0 s, d = 4.0 m
   •⟶ At t = 10.0 s, d = 5.0 m

   a) Express the data above numerically in the form of a data table. Construct the data table horizontally. Be sure to label the rows correctly.

   b) Now construct a graph of the data above.

(continued)

Learning Activity 1.1: Recording Data (continued)

c) To illustrate the symbolic mode, determine the mathematical equation that relates the distance and the time. Include the magnitude of the slope in your answer.

2. If you were asked by another student "What is physics?", what would you say?

Lesson Summary

Physics is not easy to define. Isaac Asimov, in tracing the development of the study of science from ancient times, made the following statements:

- In ancient times, there was no such thing as science, and certainly no physics, chemistry, or biology; instead there were "philosophers" who were literally "lovers of wisdom."
- Some philosophers studied natural phenomena and were referred to as "natural philosophers," which is pretty nearly what we would now think of as "scientists."
- The Greek word for "natural" is "physikos"—so physics was initially the same as "science" in general.
- When people eventually specialized into specific areas of study, these areas were given their own names (mathematics, astronomy, geology, chemistry, and biology) and were removed from "physics."
- What we now call physics is what remains after the above have been removed.
- Splitting up these areas of study was an artificial, somewhat arbitrary construct, and in fact these areas tend to blend into each other

The aspect of physics that we will be investigating is the study of relationships in the world we perceive around us.

In order to learn and fully understand the concepts of physics, you must look at the situation in a variety of methods called modes of representation.

For our investigation into the effect on an elastic's amount of stretch from the pull of different numbers of spoons attached to it, the following are the four modes of representation.

1. Visual Mode

   The **visual mode** gives you a picture of the phenomenon in your mind.

2. Numerical Mode

   The **numerical mode** describes the relationship using numbers.

3. Graphical Mode

   The **graphical mode** is a mathematical picture of the data.

4. Symbolic Mode

   The **symbolic mode** represents the relationship as an algebraic equation/formula.

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