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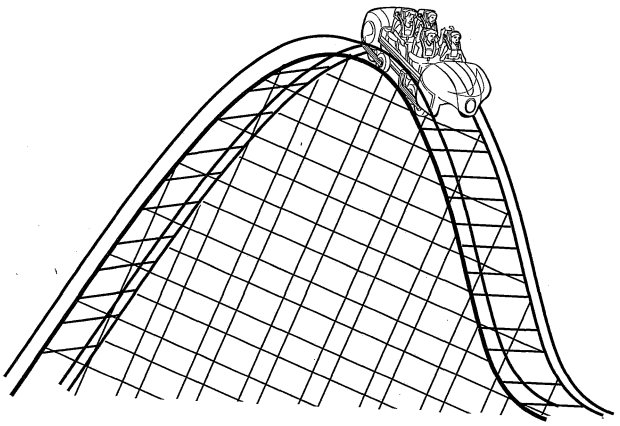
# **STEM Project** Hills, Twists, and Loops

In this project, you will be applying the concepts of energy transformation, friction, and the law of conservation of energy to something that may be familiar to you—roller coasters. Have you ever ridden a roller coaster? Did you find the ride exciting or scary? Why? What happens to the speed of a roller coaster as it goes uphill, downhill, or through a turn? What features of roller coasters make them fun—giant hills, fast turns, vertical loops? If you were to design your own roller coaster, what features would you include?



In this project you will have the opportunity to create your very own roller coaster. Your vehicle will begin its journey on top of a hill that is no more than one meter in height. (Think about the potential energy in that vehicle!) It must then travel the full length of your track, climbing over two additional hills, without stopping or falling off the track. Once you have successfully created this basic roller coaster, you will modify your track to include the more complex features, like turns and/or vertical loops.

## Project Rules

- Your first hill may not be more than one meter in height.
- Your vehicle must complete the entire track without stopping or falling off. Once you have placed your vehicle on top of the first hill, you cannot add any energy to the system to help your vehicle complete its route.
- Before you begin building your roller coaster, you must write out design plans that include the materials you plan to use and a sketch (drawn to scale) of your basic roller coaster track. Your teacher must approve these plans.
- You must make several modifications to your track. The first set of modifications will be to determine the maximum height possible for your second and third hills. The second set of modifications will be to add turns and/or vertical loops to your track.
- You must keep detailed records of any modifications that you make to your track, including the success of your vehicle's trial runs.
- You must be able to apply key terms such as *kinetic energy, potential energy,* and *energy transformation* to the description of your roller coaster.
- You must present your roller coaster to the class. During this presentation, you will have to describe all modifications that you made to your roller coaster. You will also have to show your understanding of energy transformation, friction, and the law of transformation of energy.

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## Suggested Materials

Be creative when selecting materials to use for your tracks. Some possibilities are cardboard, poster board, garden hoses, rubber or vinyl tubing, foam pipe insulation, and drinking straws. Possible vehicles include marbles, ball bearings, rubber balls, and toy cars. You may also find that you need string, tape, glue, paper clips, bricks, shoe boxes, blocks of wood, stopwatches, cups, or buckets.

## Project Hints

- Think about things that may adversely affect the performance of your roller coaster, such as friction. Can you think of ways to decrease the friction on your vehicle?
- When modifying your track, the results will be clearer if you only alter one variable at a time, such as hill height or distance between hills.

## Project Timeline

| Task | Due Date |
|---|---|
| **1.** Roller coaster building materials chosen. | _____ |
| **2.** Project design with sketch of roller coaster completed. | _____ |
| **3.** Basic roller coaster with three hills completed. | _____ |
| **4.** Maximum heights for second and third hills determined. | _____ |
| **5.** Turns and/or vertical loops added to roller coaster. | _____ |
| **6.** Make class presentation of STEM Project. | _____ |

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# Hills, Twists, and Loops

Complete the following tasks using a separate sheet of paper. When the tasks have been completed, you are ready to get your teacher's approval and begin constructing your roller coaster.

## Thinking About Energy

1. A student plans to build a roller coaster in which his second hill is taller than his first hill. Would it be possible for his vehicle to complete the track? Why or why not? Use what you have learned in your text to justify your answer.
2. A student plans to build a roller coaster in which his first and second hills are of equal height. Would it be possible for his vehicle to complete the track? Why or why not? Use what you have learned in your text to justify your answer.
3. A student plans to build a roller coaster in which his third hill is taller than his second hill. Would it be possible for his vehicle to complete the track? Why or why not? Use what you have learned in your text to justify your answer.

## Planning Your Roller Coaster

4. What materials will you be using to build your track? How will you secure your track in place? Do these materials allow you to make modifications easily?
5. What do you plan to use as your vehicle? Will your vehicle fit onto the track?
6. What is the mass of your vehicle?
7. Sketch your basic roller coaster design, including three hills. Make this sketch to scale (for example, 1 cm in this sketch is equal to 10 cm on your actual roller coaster). Remember that your first hill may not exceed one meter!
8. On the sketch of your roller coaster, indicate the following:
   - height of each hill
   - distance between hills
   - point of maximum potential energy
   - point of maximum kinetic energy

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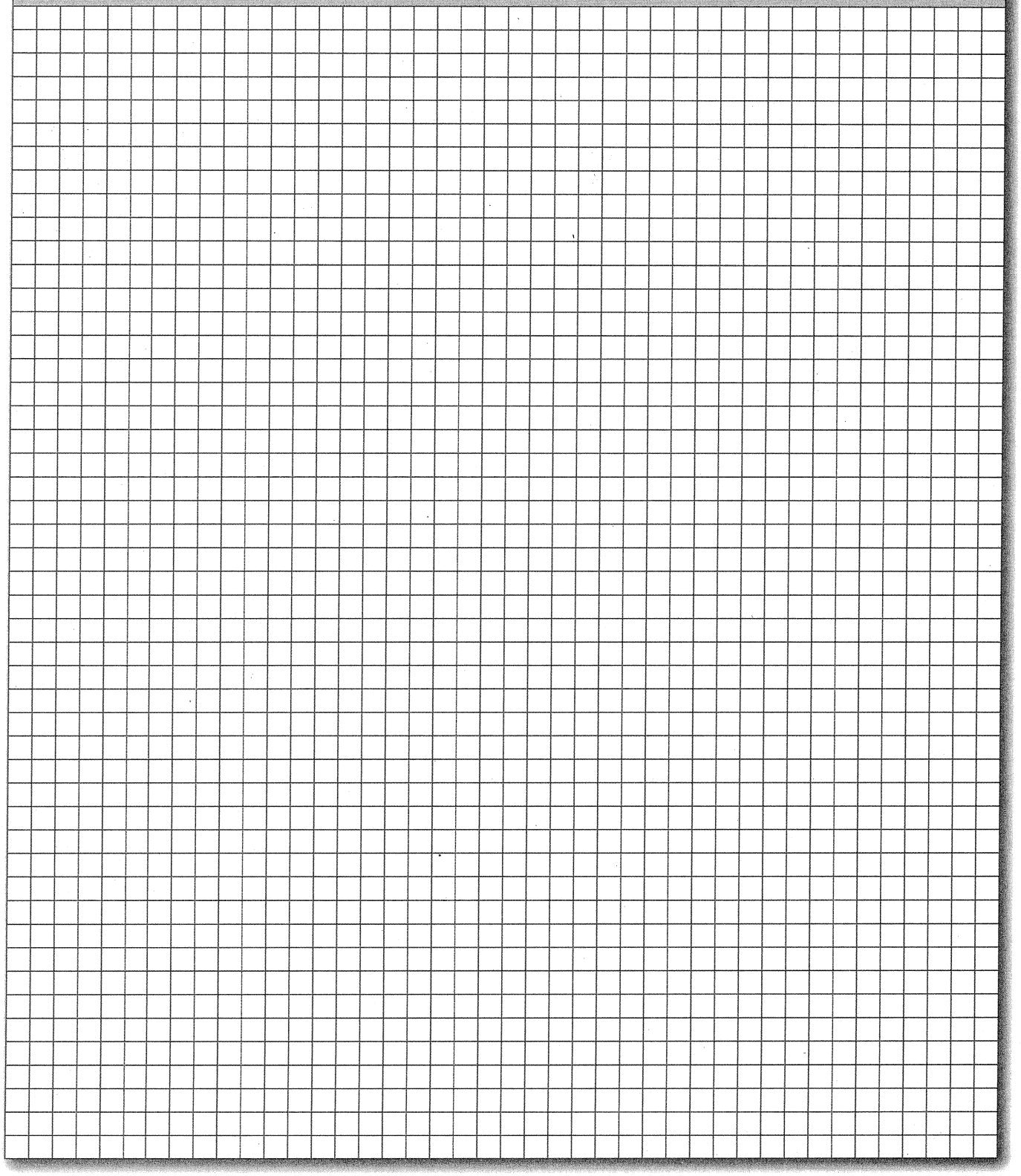
# Ideas, Drawings, and Answers



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# Hills, Twists, and Loops

## Part I: Finding the Maximum Hill Heights

Create a chart similar to the one below to record all modifications that you make to your track.

| Modification number | Variable that you changed | Variables that remained constant | Heights of second and third hills | Distances between hills of trial run | Outcome and observations |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |

Answer the following questions on a separate sheet of paper.

1. How did changing the height of the second hill affect the distance that your vehicle traveled up the third hill?
2. How did changing the distance between hills affect your vehicle's performance?
3. What was the maximum hill height that you found for your second and third hills?

## Part II: Adding Twists

Create a chart similar to the one below to record all modifications that you make to your track.

| Modification number | Variable that you changed | Variables that remained constant | Outcome and observations of trial run |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |

Answer the following questions on a separate sheet of paper.

4. How did the placement of your turn or vertical loop affect the success of your vehicle in completing the track?
5. How did adding turns and loops to your track affect your vehicle's performance on the hills?
6. What problems did you encounter in making these modifications? For example, did you have to create a barrier to keep your vehicle from leaving the track on a sharp turn?

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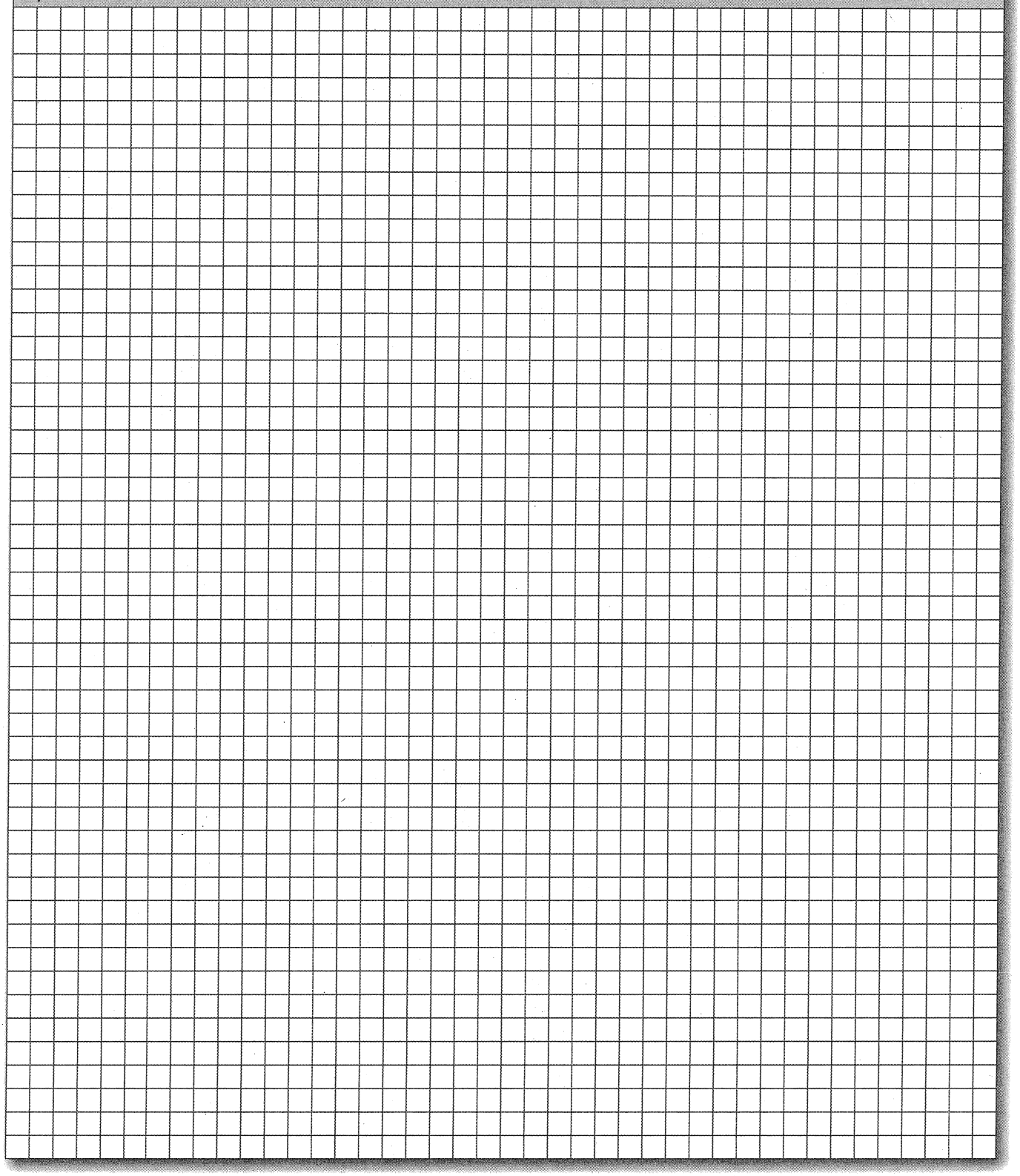
# Ideas, Drawings, and Answers



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# Hills, Twists, and Loops

In evaluating how well you complete the STEM Project, your teacher will judge your work in four categories. In each, a score of 4 is the best rating.

| | *4* | *3* | *2* | *1* |
|---|---|---|---|---|
| **Planning and Building the Roller Coaster** | The student is able to plan, and build a roller coaster, according to the specifications in which the vehicle successfully completes the track. | The student has only minor difficulties in either planning or building a roller coaster in which the vehicle successfully completes the track. | The student has significant problems either in planning or building a roller coaster in which the vehicle successfully completes the track. | The student attempts, but is unable to plan and build, a roller coaster in which the vehicle successfully completes the track. |
| **Conducting Experiments and Modifying the Design** | The student is able to make all modifications to the roller coaster. Detailed descriptions of these modifications are well-organized and recorded in a data table. | The student makes most of the modifications to the roller coaster, and data tables are fairly complete and organized. | The student makes some modifications to the roller coaster, but data tables are somewhat incomplete and disorganized. | The student makes minimal attempts to modify the roller coaster or does not keep track of modifications. |
| **Applying Concepts and Using Terminology** | The student uses chapter terms correctly in descriptions of the roller coaster. | The student uses most chapter terms correctly in descriptions of the roller coaster. | The student uses some chapter terms correctly in descriptions of the roller coaster. | The student has problems using most chapter terms correctly in descriptions of the roller coaster. |
| **Presenting the Roller Coaster** | The student makes a thorough, well-organized presentation. He or she displays well-designed visual aids. | The student makes a good presentation. He or she displays helpful visual aides. | The student makes a presentation, but it is hard to follow. He or she uses few visuals. | The student gives only a brief, poorly organized presentation. He or she uses no visuals. |

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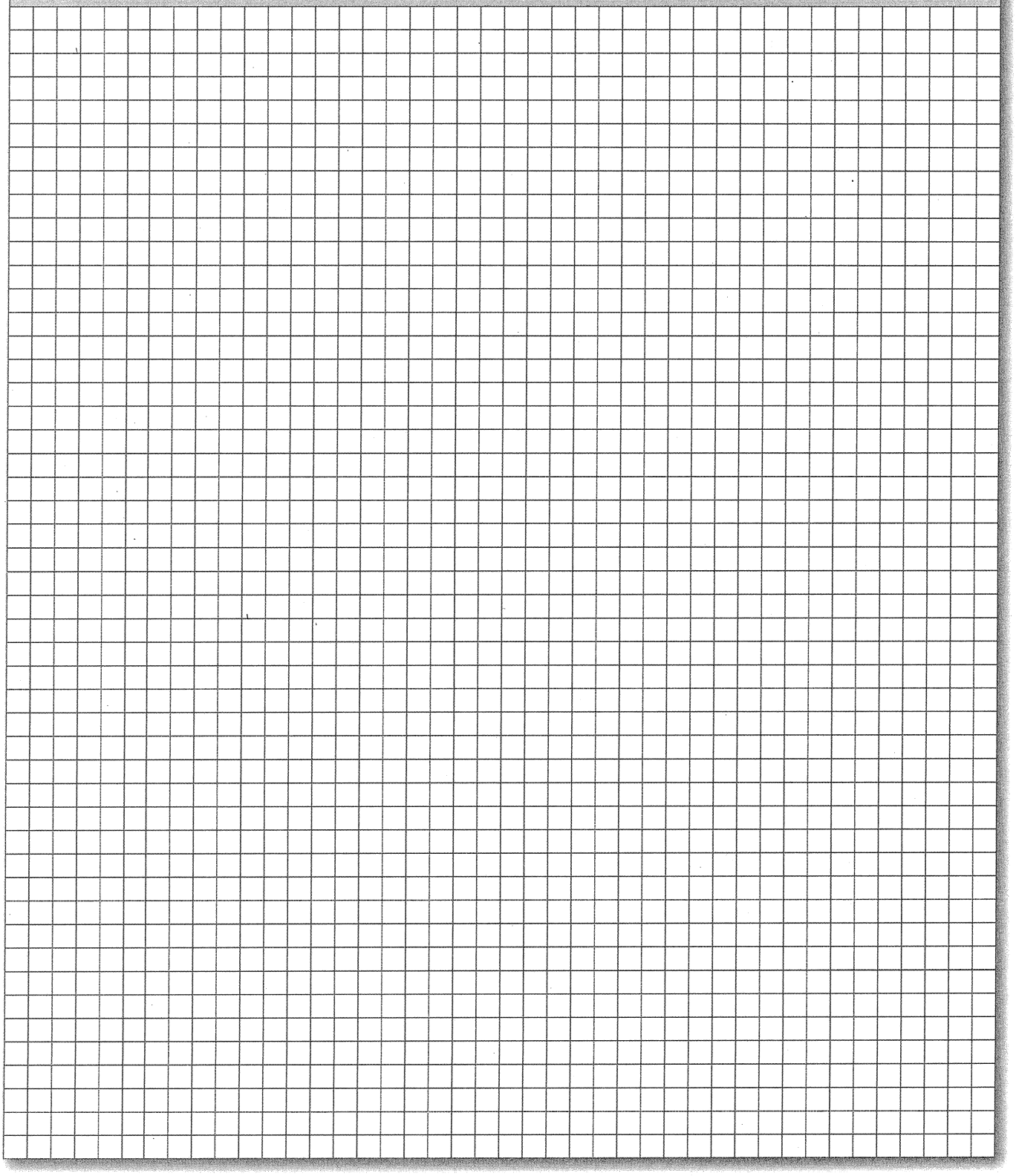
# Ideas, Drawings, and Answers



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