SCIENTIST: _____ TEACHER: _____

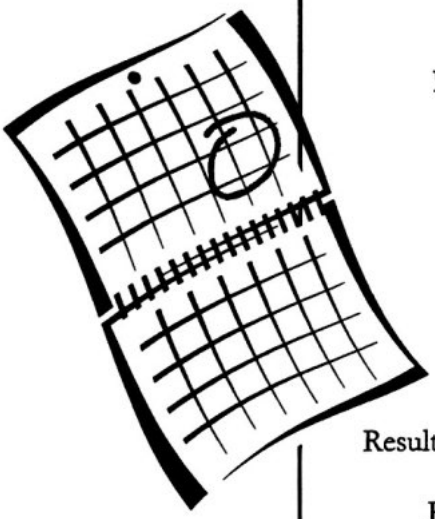
It's STEM Fair Time!!

STEM stands for Science, Technology, Engineering, and Mathematics. Over the next few months, you will choose your own research project that contains one or all of the STEM elements and conduct an investigation to seek the answer to your project's question. This long-term, at home project will enable you to combine reading, writing, math, data analysis and scientific inquiry all on a topic that you have chosen!

This handbook is meant to provide you with examples and models of each step of the STEM process. There is also a place where you will take notes and draft the elements of your project. Both you and your family, along with your teacher will all use this book to write, edit, comment and keep track of your work on each component of the STEM process.

Your teacher will give you specific deadlines for each phase of your project. Use the space below to write down your due dates. Then, turn the page and begin to brainstorm topics you might consider for your project.

Timeline for the STEM Fair Project



Component	Due Date
Question	January 18
Prediction/Hypothesis	January 25
Variables	February 1
Materials	February 8
Procedures	February 15
Data Collection Tool	February 22
Results, Actual Investigation	March 1
Results, Graph of Data	March 1
Results, Written Explanation	March 8
Conclusion	March 8
Research Paper	March 22
Display Board to School	March 27

Getting Started

There are many ways to choose a STEM Fair topic. You can start by:

- observing the world around you
- searching the internet
- looking at books in your school library
- looking at books in your public library

You can also use the list below to determine a category of STEM inquiry that interests you. This might help you narrow down your ideas.

Earth / Environment	Chemistry	Physics	Life / Biology	Engineering	Mathematics
• weather • rain • climate • erosion • wind speeds • water filtration • recycling processes • composting	• freezing • melting • burning • rusting • heat	• speed • force • friction • gravity • magnets • electricity • elasticity • weight/mass • density	• plant growth (based on: water, temperature, sunlight, soil type) • invertebrates	• bridge design • building design • machine design	• probability • number relationships • frequency analyses

As you develop your project idea, consider the following questions with your family:

- Do we have time for this project or should we choose something that is shorter?
- Do we have the space (inside or outside) for this project?
- Can we purchase all of the items for this projects or are some too expensive or too hard to find?
- Will we need to build anything and, if so, can we do it?

As you narrow down your interests to one of the categories above, consider some of the project ideas listed on the next page.

STEM Fair Project Ideas

Physical Science:

What variables affect the swing of a pendulum (length of string or mass of pendulum)?
Is there a relationship between the size and strength of a magnet?
What types of surfaces produce the greatest or least amount of friction?
What variables determine the strength of an electromagnet (number of wire wraps, wire gauge, the diameter of nail)?
What variables affect the flight of an airplane (materials, weight, shape, angle of launch)?
How does the bounce height of a ball related to the drop height?
What variables affect the efficiency of parachutes (size, shape, materials)?
Which shape of windmill blade is most efficient?
How does the length of a rotor affect helicopter flight?
Does the length of a ramp (inclined plane) affect the amount of force needed to pull a load up a ramp?
Does the temperature of the air affect air pressure?
What effect does air pressure have on the bounce of a ball?
Does mass affect how fast objects of equal volume will fall through a liquid?
How does the size of a wheel affect the rate at which it lifts a load?
What is the effect of mass on rocket trajectory?
How does temperature affect the bounce height of a ball?
Does the angle of launching affect how far a paper airplane flies?
What variables affect the distance a balloon rocket will travel (amount of air, nozzle shape, angle of ascent, different pathways)?
Which type of material conducts sound the best?
Do different types of string or string lengths affect the efficiency of a paper cup or tin can telephone?
Do different watt light bulbs produce different amounts of heat?
What effect does temperature have on buoyancy?
Does color affect the rate in which an ice cube melts?
What effect does color have on temperature?
What material makes the best heat insulator?
Which type of container keeps liquids hotter longer?
What effect does temperature have on the elasticity of a rubber band?
Do suction cups stick equally well to different surfaces?
Does the amount of stretch of a rubber band affect the distance a rubber band will travel?
What design shape supports a bridge the best?
What shape of container allows for greater rates of evaporation?
How is the strength of a magnet affected by glass, cardboard and plastic?
What is the relationship between temperature and amount of carbonation in soft drinks?
Do basketballs that are fully inflated bounce better than flatter ones?
Do all liquids freeze at the same rate?
Does the depth of a pan affect how water freezes?
Do different types of liquids have an effect on the rate of oxidation?
Does viscosity (thickness) of a liquid have an effect on the rate of evaporation or the boiling/freezing point?
Does iron rust faster in salt or fresh water?
What coating inhibits rust formation the best?
Does hot water freeze at a different rate than cold water?
Which will food coloring mix into faster - hot, medium, or cold water?
Which chemicals slow the browning of apples or other fruits?
What food dry cells (tomato, potato, or apple) will produce the highest amount of energy measured in voltage?
What effect does temperature/packaging have on the ripening of bananas?
Does temperature have an effect on solubility? Does the color of water have an effect on evaporation rate?
Does temperature affect the growth of sugar or salt crystals?
What materials melt an ice cube most efficiently?
How does temperature affect the reaction rate of Alka Seltzer?
Do heavier objects fall faster than lighter ones?
Does the density of wood affect how much weight different pieces of wood will hold in water?
Do water purifiers really work?
How well do different types of wood absorb water?
What type of metal, steel, copper, or bronze, will rust faster?
What liquid works best in making invisible ink?
Do watches keep the same time?

Mathematics:

What are the most common sums of two dice when rolled?
What is the relationship between height and arm length?
What is the probability of reaching into a bin and selecting a particular color of M&M candy? Can statistics be used to predict the contents of edible consumer products such as fruit snacks, a bag of jelly beans or M&Ms?
Which juice box manufacturer has the largest volume of juice and uses the least amount of packaging material?
How do the dimensions of a rectangular prism change with respect to each other?
Does the probability of drawing a particular card from a deck depend upon the number of that type of card in the deck?

Computer Science:

Does the font style of the letters (or characters) in a file change the size of the file?
How does the file size change as more letters (or characters) are added to a file?
How do snow crystals grow?

STEM Fair Project Ideas

Life Science:

Do different colors of light affect the growth of plants?
Do seeds germinate at different rates?
Does the placement of a seed when planted affect the growth of the seed?
Do vitamins or fertilizers affect the growth of plants?
Does acid rain have an effect on the germination of seeds?
Does temperature affect the growth of seeds or plants?
Which fruits or orange drinks have the most vitamin C?
Which plants and vegetables make the best dye?
Does the type of water affect the growth of plants?
Is soil necessary for plant growth? (hydroponics study)
Does music affect plant growth?
Does a plant grow best in sunlight or artificial light?
Can plants deprived of sunlight recover?
Can newspaper be recycled to be used to fertilize plants?
How does the concentration of salt in water affect seed germination?
Do beans grow better in clay, sand or potting soil?

Environmental:

What kind of soil is best for water retention?
Does recycled paper break down faster than new paper?
How does the clarity of a body of water change over time?
Are there differences in the amount of air pollution inside vs. outside a building?
What kinds of garbage break down the fastest in a landfill?
What is the effect of acid rain on plant growth?
What effect does fertilizer have on algae growth?
Which environmental pollutant, motor oil or used antifreeze, has the greatest effect on plants?
Does using gray water (bath or hand washing) effect plant growth?
Does rain or hail create more erosion on a slope?
Does vegetable waste (banana peels, apple cores, etc) decompose faster in soil with earthworms?
Which soil cover prevents the most soil erosion (grass, mulch or bare soil)?
How are different soil types affected by erosion?
Which food group decomposes the quickest?
How does water collected while bathing, washing a car, or animal affect plant growth?
Do temperatures change when materials are composted?
What items are recycled the most in your home or community?
How many plastic bags does your family collect on a monthly basis?
What is the average number of plastic bags collected by 10 families in your community in a period of time (week, month)?
How much garbage does your family produce over a month and what percentage is recycled or could be recycled?

Earth Science:

Are there differences in temperature in shaded versus non-shaded areas during the day and at night?
How accurate are local forecasters?
Do weather conditions affect the broadcasting of AM radio stations?
What materials or methods work best for cleaning up oil spills?
Are different sizes and shapes of sand dunes formed by differing wind speeds?
How quickly does a creek change water temperature in comparison with air temperature?
How well does charcoal filter water?
Which material absorbs heat most efficiently, sand, soil, or rocks?
Do different types of soils have different percolation rates?
What effects do the changes in the length of day and night have on household plants?
Will the size of a crater be greater when the impact object is bigger? Or travels faster?
How accurate are long-range weather forecasts?
Is rainwater absorbed at the same rate in different kinds of soil?
How accurate are homemade weather instruments?

Engineering:

What factors affect the top speed of a radio-controlled car?
Does the material of a parachute affect how fast it drops?
What levee construction will hold the most water?
Which folded paper structure will support the most stress?
Which truss design will withstand the most weight?
Will the amount of material that will be eroded change as the slope angle increases?
Does the area of a parachute affect how fast it falls?
Which building design best withstands an earthquake?

Scientific Method

Question

What do you want to learn more about?

Research

Find out what is already known about the topic?

Hypothesis

What do you THINK will happen based on what you know?

Procedure

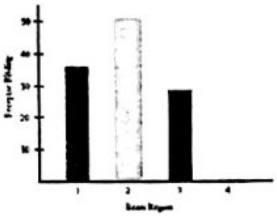
Write and follow every step of the experiment designed to test your hypothesis.

Experiment

Do at LEAST **3 trials.**

Data

Collect information and record using charts and graphs.



Observations

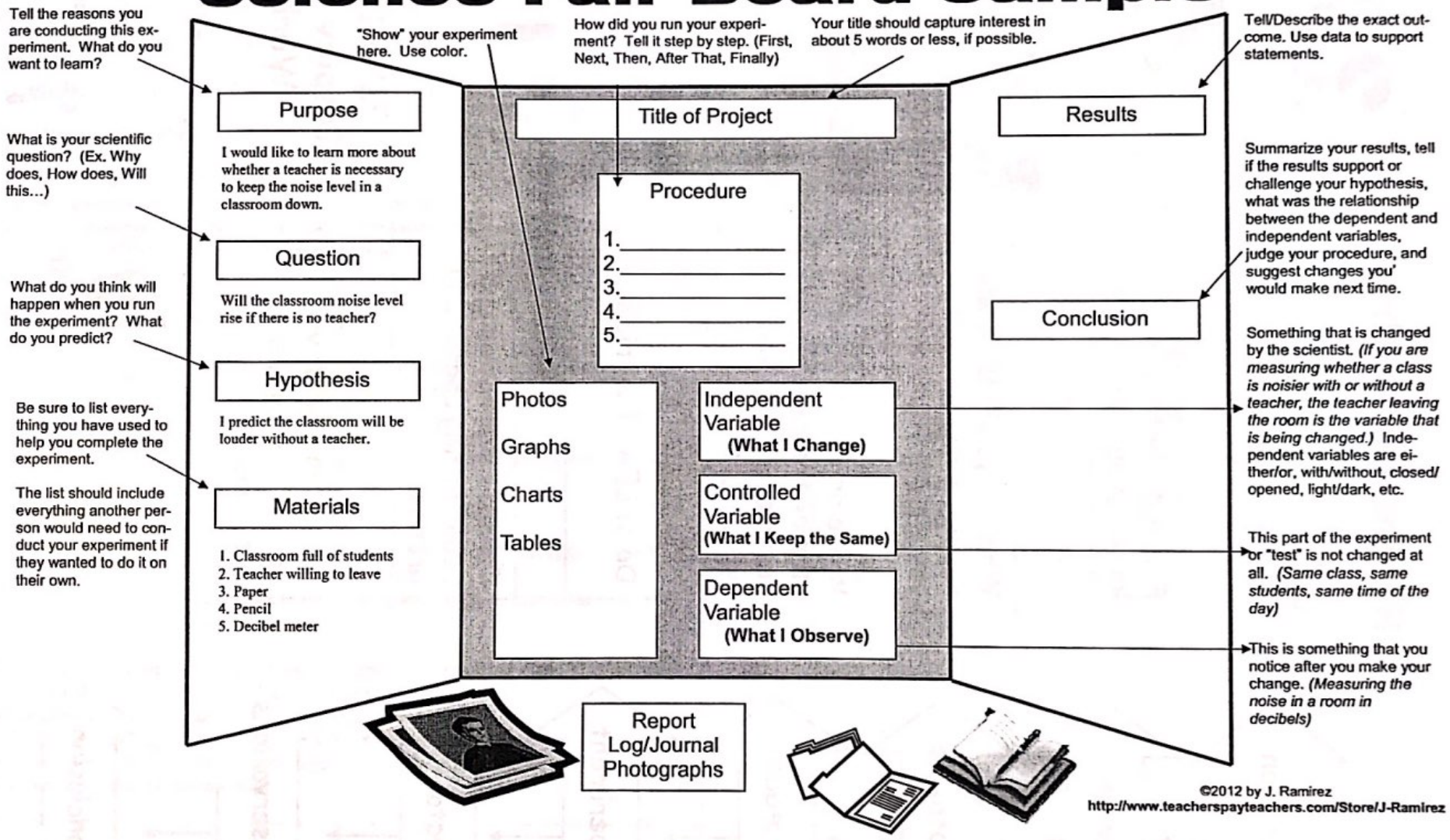
Write down what you noticed during the experiment.

Conclusion

Was the hypothesis correct or incorrect? What would you change, or what else do you want to know?

FINALLY: Display Your Work!!

Science Fair Board Sample



Question

Your Question is the specific problem, topic or question you plan to investigate. The results or answer for your question can only be found by a hands-on investigation.

Good Example:

- Does weight affect how fast a pendulum swings?

This is a good example because you begin your question with a very basic wondering.

Bad Example:

- How does weight affect how fast a pendulum swings?

This is a poor example because when you use the word "how" you already assume you can change the pendulum's speed.

My question is: _____

_____

_____

_____

_____

☐ Your question is approved!

☐ Your question is not approved. Use my comments to re-write your question. Your new due date for your question is: _____

Teacher Signature:_____ Date: _____

Parent Signature:_____ Date: _____

Hypothesis / Prediction

Hypothesis is a synonym for a prediction. After you ask your question, you try to predict what the answer will be based on your own background knowledge from either research or everyday observations. You must always give a real-world reason for your hypothesis.

Model Question: Does weight affect the speed of a pendulum?

Model Hypothesis Example:

There is a reason for the hypothesis with a specific example from the student's own experience.

The student gives a definite answer to the question

- I think weight does affect the speed of a pendulum because when my big brother and I are swinging, he always goes faster than I do and he weighs more than I do so weight can change the pendulum.

Bad Hypotheses Examples:

No definite prediction was made.

- Weight might change the speed because I have seen swings moving at different rates.
- Weight can't change the speed of a pendulum because I have never seen it done before.

This reason doesn't prove the prediction "can't." Just because you haven't seen it doesn't mean it hasn't happened.

My hypothesis is: _____

_____

_____

_____

☐ Your hypothesis is approved!

☐ Your hypothesis is not approved. Use my comments to re-write your hypothesis. Your new due date for your hypothesis is: _____

Teacher Signature:_____ Date: _____

Parent Signature:_____ Date: _____

Variables

A variable is something in your experiment that you change on purpose, wonder if it will change or if you force it to stay the same. All experiments have three (3) types of variables.

1. Independent Variable: You, as the scientist, change this in your experiment on purpose. Sometimes it is called the manipulating variable. You can only have one (1) per experiment.

2. Dependent Variable: This is what might change in your experiment based on your independent variable. Sometimes it is called the responding variable because it acts in response to what the independent variable did.

If you have a well-written question, your independent variable and dependent variable are already identified.

3. Controlled Variables: These are parts of the investigation you keep the same so they don't "interrupt" what the independent variable is doing and how the dependent variable is reacting.

You will change this on purpose.

You wonder if this will change.

Model Question: Does weight affect the speed of a pendulum?

Model Variables:

- Independent Variable – weight of the pendulum; you will add or take away weight to the pendulum with each set of trials
- Dependent Variable – speed of the pendulum; you don't know if this will change as you add or take away the weight.
- Controlled Variables – length of string used; type of string used; amount of time for each set of swings; starting "drop point" of the pendulum

String and a stopwatch were listed in your materials so you need to explain how you will control their use.

Use your materials list and your procedures to help you generate the controlled variables. There will be a different amount of controlled variables for different experiments.

My variables are:

- Independent Variable: _____
- Dependent Variables: _____
- Controlled Variables: _____

_____

_____

☐ Your variables are approved!

☐ Your variables are not approved. Use my comments to re-write your variables. Your new due date for your variables is: _____

Teacher Signature:_____ Date: _____

Parent Signature:_____ Date: _____

My revised variables are:

- Independent Variable: _____
- Dependent Variables: _____
- Controlled Variables: _____

_____

_____

☐ Your variables are approved!

☐ Your variables are not approved. Use my comments to re-write your variables on a separate piece of paper. Your new due date for your variables is: _____

Teacher Signature:_____ Date: _____

Parent Signature:_____ Date: _____

Materials

Your materials are a list of the items you will need to conduct your experiment. As you develop your procedures on the next pages, you may need to add to this list.

Remember to list specific amounts of items and to always use metric measurements. Some standard measurement units are listed below to help you.

Model Materials Example

Quantity and Description	
5	plumbing washers of equal size for the weight
5 pieces, 35 cm each	twine or string
2	metric rulers
1	stopwatch
1 roll	masking tape
1	scissors

Specific amounts are provided; metric ruler is used; specific type of weight is mentioned.

Bad Materials Example

Quantity and Description
weights
pieces of string
stopwatch

No specific amounts are given nor is the type of measuring ruler listed. The list also leaves out materials that will be needed for the investigation.

Materials List (You may need more or less lines. If you need more, attach a sheet of paper)

Quantity	Description

☐ Your materials list is approved!

☐ Your materials list is not approved. Use my comments to re-write them. Your new due date for your list is: _____

Teacher Signature:_____ Date: _____

Parent Signature:_____ Date: _____

Procedures

Procedures are a detailed list of step-by-step directions of how to conduct your experiment. Using specific details are very important to procedures – using exact amount of materials, the time it will take for parts, etc. The goal for procedures is for someone to follow the experiment exactly as you meant for it to be conducted without having you there to explain the directions. Remember, you must repeat the activity a minimum of three (3) times!

Model Question: Does weight affect the speed of a pendulum?

Model Procedures Example:

1. Gather all materials.
2. Cut my sting into a piece that is 34cm long.
3. Tape one end of my string to a table so 30 cm are hanging off the side of the table.
4. Tie one plumbing washer to the free end of the string.
5. Lift the washer to the bottom of the table and release.
6. Start timing when the washer is released and continue timing until the pendulum has completed ten complete swings (back and forth).
7. Repeat 5 times and find the mean of the times. Record all data collect on the data chart.
8. Add one more washer to the string.
9. Repeat steps 4-7 with two, three, four and five washers on the string.
10. Compare the means of the data to draw conclusions.

Bad Procedures Example:

1. Gather your materials and ask mom for permission to work in the kitchen.
2. Tie one weight onto the end of the string.
3. Swing the pendulum 10 times and time how long it takes to swing.
4. Write down your answer.
5. Do it all over again until you have used all of the weights.

These procedures are not clear. The reader would not be able to recreate your experiment

My Procedures (You may need more or less lines. If you need more, attach another piece of paper.)

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

☐ Your Procedures list is approved!

☐ Your Procedures list is not approved. Use my comments to re-write them. Your new due date for your list is: _____

Teacher Signature:_____ Date: _____

Parent Signature:_____ Date: _____

Data Collection Tool

You will need a place to write down your data as you conduct your trials and make your observations. You collection tool can be a table and must include the following items:

- a title
- labels to describe the columns or rows
- space for repeated trials (a minimum of three; more is better!)
- space for the a calculation of the median of the data and the mean (average) of the data, if required by your teacher
- all data is collected in metric units (see Materials p. 14 for a reminder)

If you are not collecting numerical data but rather making observations, you still need to design a chart or keep a journal in which you can record your detailed notes. This is most typical with projects that involve the growth or decay of something.

Model Question: Does weight affect the speed of a pendulum?

Model Data Collection Table

Independent Variable

Dependent Variable Summary

Effect of Weight on Speed of Pendulum

Weight of Pendulum	Trials Recorded in Minutes and Seconds					Median Time for 10 Swings	Mean Time for 10 Swings
1 weight							
2 weights							
3 weights							
4 weights							
5 weights							

Dependent Variable Individual Results

My Data Collection Tool

Use this space to design your own data collection tool or use a table. * You may type and attach to this page.

☐ Your data collection table is approved!

☐ Your data collection tool is not approved. Use my comments to re-create it on a separate piece of paper. Your new due date for your table is: _____

Teacher Signature:_____ Date: _____

Parent Signature:_____ Date: _____

Results, Data from Experiment

Now you are all ready to conduct your experiment. All of the work you have done up to this point has prepared you for a thorough investigation on your topic. Before you begin your experiment, remember to:

- Gather all the materials you listed
- Have an adult present if your investigation requires it
- Follow the procedures just as you wrote them
- Keep accurate records by filling in your data chart as you go

REMEMBER!

- If you are growing something (plants, mold) plan to allow a minimum of two weeks (approximately 14 days) for everything to grow enough for you to have a meaningful amount of data
- If you are freezing something, plan to allow a minimum of four hours for liquids to freeze completely so a meaningful amount of data can be collected
- If you are melting something, plan to allow an appropriate amount of time depending if you are melting the item in an oven or just by natural temperature
    - If you are using an oven, remember to have an adult present.

Do not begin to graph your data until your teacher has approved the data you collected in your table.

☐ Your Experiment Data is approved!

☐ Your Experiment Data is not approved. Use my comments to re-create it on a separate table. Your new due date is: _____

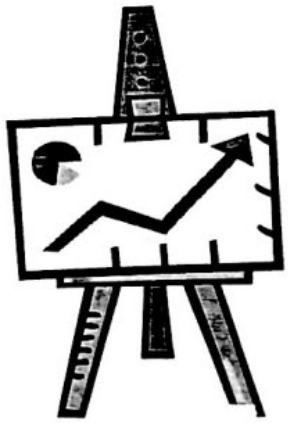
Teacher Signature:_____ Date: _____

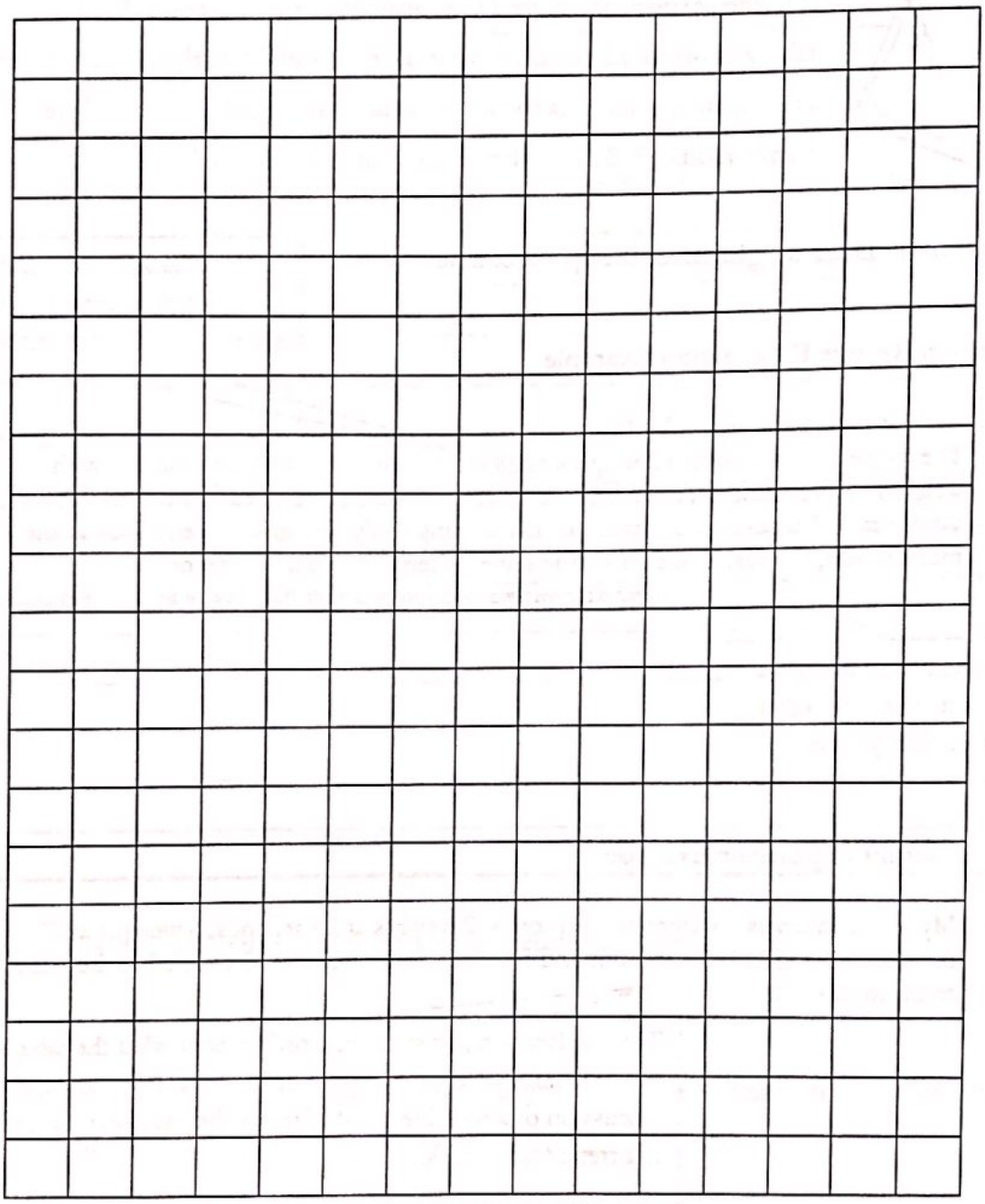
Parent Signature:_____ Date: _____

Results, Graphic Display

Once your teacher has approved the data you have collected in your table and you have summarized the data by finding the median, mean or some other method of highlighting the important results, you are ready to graph your data. Here are the steps to organize your material:

- You must choose the correct type of graph to display your results.
  - Line graphs should be used to display continuous data – information that changes over time.
    - temperature changes (not just a final, ending temperature)
    - growth changes
    - time changes
  - Bar graphs should be used to display data that is separate or distinct from other pieces of data in your activity.
    - height of bouncing or falling objects
    - distance objects travel
    - survey results
  - Pie charts, line plots and stem/leaf plots are not usual graphical displays in STEM projects. Please check with your teacher first if you are considering one of these types of displays
- All graphs need to include the following information
  - title – this can be the same as your data collection table
  - independent variable – this goes on the horizontal (x-axis); you can use what you have on the data collection table
  - dependent variable – this goes on the vertical (y-axis); use the same description as the data collection table
- If you only present one graphic display, it must be the summary data (median, mean)
  - You can present a graphic display of all of your data but it must be in addition to the summary graph
- You may use the graphing paper on the next page or select a graphing tool of your own.
  - On the provide graph, space has been left around the perimeter for all of the labels and to use it portrait or landscape style.
  - Computer-generated graphs are allowed but be sure they contain all of the information listed above.





Results and Written Explanation

A written explanation gives a brief analysis of the data you collected in your table and displayed visually in your table. It should be about one paragraph and summarize the data shown in the table and graph. It can include trends you noticed in the data, if any, but it should not be a conclusion.

Model Question: Does weight affect the speed of a pendulum?

Model Written Results Explanation Example:

- The mean (average) time for 10 swings was approximately the same for all the weights. The longest time was with 2 weights at 28 seconds and the shortest time was with 5 weights at 24 seconds. However, since these times are close to each other and so are the other times, I would say the trend is that nothing really changes. When I look at the median data, the results are about the same – there is no real difference.

(This data was made-up just to demonstrate how to write an explanation.)

This explanation summarizes the data by only mentioning the shortest and longest piece of data.

There is an attempt to discuss a trend to the data even though a trend isn't completely clear.

Bad Written Results Explanation Example:

- My mean data was 1 weight at 26 seconds, 2 weights at 28 seconds, 3 weights at 27 seconds, 4 weights at 25 seconds and 5 weights at 24 seconds. I can't tell if there is a trend to this data.

This explanation just states in words exactly what the table says. It doesn't summarize the most important data nor is there any brief discussion of a possible trend. Stating that you "can't tell if there is a trend" is not an analysis.

Here is the written explanation of my results.

☐ Your Results and Written Explanation is approved!

☐ Your Results and Written Explanation is not approved. Use my comments to re-create it on a separate piece of paper. Your new due date is: _____

Teacher Signature:_____ Date: _____

Parent Signature:_____ Date: _____

Conclusion

The conclusion tells what you learned about the topic after completing the experiment. It contains many parts. Use the question prompts below to organize your ideas. Then, join them together into multiple paragraphs to create your final conclusion.

What is the answer to the question your asked?

Re-read your hypothesis. Was it correct?

What can you infer about your results?

How can this information help you, others or even companies in the real-world?

Did you have any problems as you conducted your investigation?

If you kept the same topic, what different idea would you test next year?

_____

_____

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_____

☐ Your Conclusion draft is approved! Next, go to p. 28 to work on your combining your Conclusion statements into one final product.

☐ Your Conclusion draft is not approved. Use my comments to re-create it on a separate piece of paper. Your new due date is: _____

Teacher Signature:_____ Date: _____

Parent Signature:_____ Date: _____

Research Paper Guidelines

The research paper is an important part of any good STEM fair project. The research paper gives you an opportunity to learn more about your topic and should be closely related to the investigation you have chosen for STEM fair. The research paper is **MANDATORY** for all projects submitted. The research paper is not complicated and only needs to include the following **five parts**:

1. Title Page – includes the title of your project, your name, school, grade, teacher, and the date the project is due

2. Acknowledgements – a personal thank you to anyone who helped you with the project. It could include parents, teachers, siblings, librarian, scientist and any other person who assisted you with any part of your project.

3. Question – the specific question you ask for your experiment. This can be placed on its own page or right before beginning the research portion of your research paper.

4. Background Research –

    a. Start by brainstorming topic ideas. Think of other questions you have about your topic and make a list.

    b. Use books from the library and the internet to find out interesting and relevant information about your topic.

    c. Rewrite the information you find in your own words. Do not copy from the book or print pages from the internet. This is **PLAGARISM** and it is illegal. If you need help, ask an adult for assistance.

    d. Make sure to keep track of all the books, websites and articles you used to get your information so you can list your sources in your bibliography.

5. Sources/Bibliography – an alphabetical listing of books, articles, and other sources, including websites, that you used when researching your topic. Visit http://easybib.com for an explanation of how this should be written.

6. Follow the directions provided by your teacher to complete your research project.

Appendix D: Tips for Creating Outstanding Display Boards

- ☐ **Be Neat** – Avoid frayed or ripped edges of paper, glue globs, lots of cross outs or white outs etc.

- ☐ **Use Colors to Attract Attention** – Use no more than three colors on your project board. Too many colors can be distracting.

- ☐ **Frame or Matte Your Work** – Use construction paper, or other materials, to provide a background for your written work and labels.

- ☐ **Choose a Good Title** – Titles should be short, catchy and related to your topic.
  - For example, Cool Color Cubes is better than The Melting Rate of Different Colors of Ice Cubes

- ☐ **Writing Should Be Neat** – If possible, everything on your board should be typed, making sure that you use the same fonts and font sizes throughout. Do not go overboard with fonts, font colors or font sizes. Try to keep everything looking uniform. If you are hand writing, use pen and write very neatly so that everything can be read. Cursive is not encouraged.

- ☐ **Spelling Counts** – Have an adult check all of your spelling before printing.

- ☐ **Practice the Layout** – Before you glue anything to your board, lay it all out to make sure it fits. If items are too small make them larger, if items are to large make them smaller. You do not want things to overlap and you do not want too much white space.

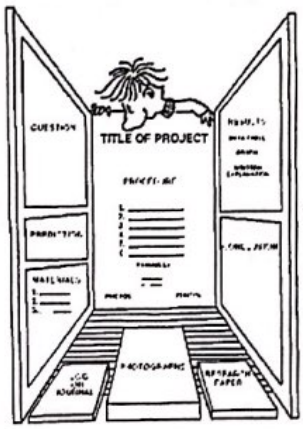
- ☐ **Do Not Glue Any Materials From Your Project*** – Only paper and photographs are allowed on your board. If you want to put a material on your board, take a picture of it and glue that on your board.

- ☐ **Do Add Photos and Drawings** – This is the best way to clearly shows what you did during your investigation.

*Pictures can not include faces of students.

- ☐ **Research Papers Should be Placed on the Table in Front of Your Board** – DO NOT attach the research paper to your backboard.

- ☐ **Select the Right Size*** – Choose a board that is no larger than 100cm wide and 95 cm high.



PHOTOS MAY NOT SHOW STUDENTS' FACES.

DO NOT USE SCHOOL NAME OR STUDENTS' NAMES.