SPRING CONSTANT ~ ELASTICITY CONSTANT

Note: *In this lab, you will be graded against the old internal assessment criteria. While this criteria no longer applies to your IB grade, it is a good rubric for a comprehensive lab report. The design portion has been written for you below. You will be responsible for the data collection and analysis, and for the conclusion and evaluation portion of the assessment. You will work in groups of two. Each group will select their own spring and will conduct the investigation individually. Because our supply of masses and mass hangers is limited, it will require some creativity in assembling your experiment. It will also require that you cooperate with your classmates in sharing the masses. You will also have to align with a partner group to share half of a lab stand and one meter stick. There will be one balance per table group. Be sure to mark your experiment assembly with your name on a piece of masking tape in case you don't complete your data collection in one class period.*

Research Question

In the elastic range, does the spring constant / constant of elasticity of a spring remain constant over a wide range of forces applied to it? For both springs and elastic material, we have learned that the relationship between applied force and displacement is given by the equation, $F=kx$ where F is the applied force, x is the displacement or change in length of the object, and k is a constant (called the *spring constant* for springs and either the *elasticity constant* or *Young's Modulus* for elastic material). In the elastic range, i.e. where there is no permanent deformation of the material, we have always assumed that k was a constant. This lab seeks to determine whether or not the spring constant / elasticity constant varies in the elastic range when a wide range of loads is applied to it, and if it does vary, whether the variance is linear or exponential. This becomes extremely important for the design of support structures that are subjected to varying forces and must meet close tolerances.

Variables

Independent variable: applied force. For this experiment, the applied force will be the force of gravity on a variety of hanging masses. You will conduct three separate trials with 10-15 measurements in each trial. Due to limited resources, the masses used in each trial may vary which will affect the overall control of this variable, but is unavoidable. You will measure all masses under 200-g (maximum scale capacity) on a triple-beam balance. Since these scales measure to 0.1g, the uncertainty for these masses will be ±0.05-g. For masses over 200-g, you will use the value listed on the mass and will assume an uncertainty of ±1.0-g.

Dependent variables: displacement and spring constant / elasticity constant. Displacement is the change in length of the material after a force has been applied to it. The spring constant / elasticity constant, k, will be found using the equation, $F=kx$. You will use the same meter stick or ruler to determine displacement for each measurement to minimize systematic error. Since the lowest increment on the meter stick is millimeters, you will use an uncertainty of ±1.0-mm to account for 0.5-mm of uncertainty at each end of the measurement. To minimize error due to parallax, you will attempt to keep the measurements at eye level each time. To ensure that plastic deformation has not occurred in the spring, you will measure the length of the spring prior to starting the experiment, after each trial, and at the end of the experiment. For springs, you will use a 1% change in length as a benchmark for determining if deformation has occurred. In calculating the spring constant, you will use an uncertainty based on the propagated uncertainty of the mass and displacement measurements. Because of the inability to completely control the experiment set-up between trials, you will ***treat each trial separately in analyzing data to determine if the spring constant changes***.

Relevant variables: Temperature can affect the elastic properties of a spring or an elastic material. you cannot control the room temperature, but you will record the temperature prior to starting the experiment, after each trial, and at the end of the experiment to determine if it might have contributed to the results. Relative humidity could affect elasticity, more so with elastic material than for a metal spring. You have no means of measuring the relative humidity, however the room is equipped with a dehumidifier so you will assume that the effects of humidity are either negligible or constant. Another variable is the methodology you use in conducting the experiment. You will attempt to make every measurement in the same manner. Any deviations will be noted as a qualitative observation. If you make a measurement that seems to be an obvious error, you will make a note of it on your data collection sheet and will not use it in final processing. If the error is caught right away, you will re-measure three times to confirm an error occurred and use the average of those three measurements as your value for the trial.

Process

Materials:

- Spring or rubber band from the supplies offered
- Lab stand with cross-member. There will be one stand provided for each table group of 4
- Zip ties to secure springs to cross-member
- Masking tape to identify individual lab set-ups
- Triple-beam balance to measure masses less than 200-g
- Meter stick and/or ruler to measure displacement
- Room thermometer to record temperature
- Set of masses

1. Make qualitative observations throughout the experiment. Deviations from the given design should be noted on this sheet during the experiment.

2. Select either a metal spring or rubber band from the supplies offered. If you are sharing a lab stand with another group, you and your partner group should select similar materials to make mass sharing easier.

3. If using a spring, measure and record the unstretched length of the spring.

4. Secure your spring to the cross-member of the lab stand.

    a. For springs, you may use a zip tie to secure the spring to the cross-member.

    b. Make a note of the points you will be using to make your length measurements.

5. Select, measure, and record the mass of your mass hanger. Because the supply of mass hangers is very limited, you may have to use a small hooked mass as your mass hanger.

6. Take a picture of the lab set-up for inclusion in your report.

7. Record the room temperature.

8. Add a mass to the mass hanger and allow it to hang freely. Stop any movement of the hanger. Record the stretched length of your spring. If using a hooked mass as your mass hanger, use it as your first measurement. If the mass used does not appreciably change the length of the spring, do not count it as a measurement. To count, the mass must cause a distinctly measureable change in the spring's length.

9. Continue to increase the mass on the mass hanger. The total amount and the incremental increase in mass is dependent on the material you have selected. The goal is to achieve 10-15 measurements over as wide a range as possible without causing permanent deformation of the material. This constitutes one trial. While the supply of masses is limited, you should try to have a uniform distribution of masses used over the range of masses used in each trial.

10. At the end of a trial, record the room temperature and the unstretched length of your spring.

    a. If it is determined that permanent deformation has taken place in a spring based on the criteria above, you may either continue with the next trial using the new value of the unstretched spring or obtain a new but similar spring and continue with subsequent trials. Document the actions on your data collection sheet.

11. Repeat steps 10-12 for a total of three trials.

12. Put all of your materials away when data collection is complete.

Include these instructions after the cover page of your final report.

Data Collection Sheet

	Trial 1		Trial 2		Trial 3	
Room Temp Before/After						
Unstretched Length Before/After						
Number	**Mass**	**Stretch Length**	**Mass**	**Stretch Length**	**Mass**	**Stretch Length**
Room Temp						
Unstretched Length						

DEVIL PHYSICS

IB INTERNAL ASSESSMENT MARKING SCHEME

Name: ______________________ Teacher: **Mr. Smith** ______________ Date: ______________

Lab Title: ____ Topic/Option: ______________

Lab Prompt/Handout Attached ☐ Raw Data Attached ☐

Criterion		Complete (2)	Partial (1)	Not At All (0)	Level
Design	**Aspect 1** Defining the Problem and Selecting Variables	Formulates a focused problem / research question and identifies the relevant variables	Formulates a problem / research question that is incomplete **or** identifies only some relevant variables	Does not identify a problem / research question **and** does not identify any relevant variables	Complete 2 Partial 1 Not At All 0 Not Eval X
	Aspect 2 Controlling Variables	Designs a method for the effective control of the variables	Designs a method that makes some attempt to control the variables	Designs a method that does not control the variables	Complete 2 Partial 1 Not At All 0 Not Eval X
	Aspect 3 Developing a Method for Collecting Data	Develops a method that allows for the collection of sufficient relevant data.	Develops a method that allows for the collection of insufficient relevant data.	Develops a method that does not allow for any relevant data to be collected.	Complete 2 Partial 1 Not At All 0 Not Eval X
ta Collection and Processing	**Aspect 1** Recording Raw Data	Records appropriate quantitative and associated qualitative raw data, including units and uncertainties where relevant.	Records appropriate quantitative and associated qualitative raw data, but with some mistakes or omissions.	Does not record any appropriate quantitative raw data **or** raw data is incomprehensible.	Complete 2 Partial 1 Not At All 0 Not Eval X
	Aspect 2 Processing Raw Data	Processes the quantitative raw data correctly.	Processes the quantitative raw data correctly, but with some mistakes and/or omissions.	No processing of quantitative raw data is carried out **or** major mistakes are made in processing.	Complete 2 Partial 1 Not At All 0 Not Eval X
	Aspect 3 Presenting Raw Data	Presents processed data appropriately and, where relevant, includes errors and uncertainties.	Presents processed data appropriately, but with some mistakes and/or omissions.	Presents processed data inappropriately **or** incomprehensibly.	Complete 2 Partial 1 Not At All 0 Not Eval X
Conclusion and Evaluation	**Aspect 1** Concluding	States a conclusion, with justification, based on a reasonable interpretation of the data.	States a conclusion based on a reasonable interpretation of the data.	States no conclusion **or** the conclusion is based on an unreasonable interpretation of the data.	Complete 2 Partial 1 Not At All 0 Not Eval X
	Aspect 2 Evaluating Procedure(s)	Evaluates weaknesses and limitations.	Identifies some weaknesses and limitations, but the evaluation is weak or missing.	Identifies irrelevant weaknesses and limitations	Complete 2 Partial 1 Not At All 0 Not Eval X
	Aspect 3 Improving the investigation	Suggests realistic improvements in respect of identified weaknesses and limitations.	Suggests only superficial improvements.	Suggests unrealistic improvements.	Complete 2 Partial 1 Not At All 0 Not Eval X