A Sample Assessment Task for Type 2:
Analysis of Data for sets of washers bouncing on a spring

The description of this type of task is: 'Analysis and evaluation of primary and/or secondary data including data plotting, identified assumptions or data limitations and conclusions'.

This example uses video footage to generate data for an analysis task.

Introduction:
This assessment task makes use of data that was generated by Vicphysics to enable students to conduct experimental investigations while they were in lockdown during COVID.

A number of investigations were recorded on video so that students could use Tracker to extract data from the videos and then analyse their data. In this sense the data is primary data, but the students did not design the experiment or set up the equipment. The videos were on the Vicphysics Google Drive to which teachers were given access on request.

The investigations that were available included:

- How does the strength of the magnetic field between two bar magnets varies with separation as measured with a top loading balance.
- How does the strength of the magnetic field between two disc magnets varies with separation as measured with a top loading balance.
- How does the magnitude of the electrostatic attraction between a charged rod and a metal sheet varies with separation as measured with a top loading balance.
- How does the energy loss and the force of impact of the bounce of a basketball varies with drop height.
- How does the energy loss, force of impact and compression of a spring vary when a set of metal washers fall down a rod onto the spring from various heights.
- How does the energy loss, force of impact and compression of a spring vary when a sets of metal washers of different mass, fall down a rod onto the spring from a fixed drop height.

Each topic had several videos covering different trials for different values of independent variables.

To use one of these topics as a resource as an assessment task, the students could each extract the data from one or more videos and then share their data with their classmates. The students would then have a common set of data with which to conduct their individual analysis and evaluation. If teachers wish to use the videos o the Google Drive, they should send a request to Vicphysics at sec@vicphysics.org .

Topic 5 is described below. Topic 6 is conducted in a similar way, they use the same equipment, but have different independent variables.

The information provided at the time was as follows:

Aim: How does the energy loss, force of impact and compression of a spring vary when a fixed set of metal washers fall down a rod onto the spring from various heights?

Hypothesis: Students can treat this as an open investigation, seeking to find out how the dependent variables vary with drop height.

Equipment:

- A set of five metal washers
- A wooden rod with base support
- A spring
- Blutac to prevent the spring rebounding
- Fine Copper wire and connecting wires
- Mobile phone to video the experiment

Measuring instruments:

- Electronic timer
- Tape measure with cm numbered and mm marked every 2mm. The end of the tape measure was at the top. The top of the spring was at 107.0 cm and the bottom of the spring as at 118.0 cm
- Top loading balance: mass of the set of washers = 16.78 g

Description:

The set of washers is dropped down the wooden rod from a known position on the tape measure onto the spring. The washers rebound and continue to bounce. The rebound height becomes the drop height for the next bounce. The electronic timer records the cumulative impact times.

Method used:

1. The washers are raised up the rod until the bottom of the washers is at the specified position.
2. The video is turned on and the washers are released, recording motion of the washers and readings on the timer.
3. After several bounces the video is stopped.
4. Steps 1 - 4 repeated three times for this position on the tape measure.
5. Steps 1 – 5 are done for various positions on the tape measure.

AV:

Four or more trials from each of the following positions on the tape of 10.0 cm, 20.0 cm, 30.0 cm, 40.0 cm and 50.0 cm, 23 in all, and one photograph of the equipment layout. The image of the washers is blurred when they are moving, but clear in the frame at the rebound heights and at the bottom. Some videos may produce outlier results.

Using this Activity as an Assessment Task for Unit 3 Area of Study 1: Motion

1. What data to collect. As the focus is on the activity as an assessment task rather than as an investigation, the students need only focus on the first bounce and record the drop height, first rebound height, the impact time and possibly the compression of the spring and not worry about subsequent rebounds.
2. Collecting the data. Depending on the number of students in the class, students use Tracker to each work on a small number of the trials, so that at least three trails for each height are analysed. With a large class, having students analysing the same trial adds another dimension to the uncertainty in the data. The extraction of data from the videos could be done in class or as a homework exercise.
3. The data is collected by the teacher and compiled into a spreadsheet. The uncertainty of the digital readout of the electronic timer is determined by the instrument. The uncertainty in the rebound height is determined by scale on the tape measure, but more importantly by the repeated trials.
4. <u>At SAC time</u> the students are each supplied with a copy of the spreadsheet and then begin their analysis.
    a. Students use the different readings to calculate values for energy loss or efficiency and force of impact for each drop height. Including averages and uncertainties for each dependent variable.
    b. Graphs of energy loss, force of impact, impact time and compression against drop height can be drawn.
    c. Students may draw additional graph(s) if there is a suggestion of a non-linear relationship.
    d. Students describe the graphs.
    e. Students prepare the conclusions and enter within the spreadsheet.
    f. Students submit their completed spreadsheet.
    g. Additional questions could be asked to show their working for calculation of derived quantities as well as the topics of force and energy in springs, force and momentum in collisions and conservation of energy.

Relevant dot points

- investigate and analyse theoretically and practically impulse in an isolated system for collisions between objects moving in a straight line: $F\Delta t = m\Delta v$
- investigate and apply theoretically and practically the concept of work done by a force using:
  - work done = force × displacement
  - work done = area under force vs distance graph (one dimensional only)
- analyse transformations of energy between kinetic energy, elastic potential energy, gravitational potential energy and energy dissipated to the environment (considered as a combination of heat, sound and deformation of material):
  - kinetic energy at low speeds: $E_k = \frac{1}{2}mv^2$; elastic and inelastic collisions with reference to conservation of kinetic energy
  - elastic potential energy: area under force-distance graph including ideal springs obeying Hooke's Law: $E_s = \frac{1}{2}kx^2$
  - gravitational potential energy: $E_g = mg\Delta h$ or from area under a force-distance graph and area under a field-distance graph multiplied by mass.

Performance Descriptors for selected Content Knowledge and relevant Key Science Skills

Content Knowledge	**Very high**	**High**	**Medium**	**Low**	**Very low**
Linear Motion	Calculates values and directions of non-perpendicular forces acting on a body	Calculates values and directions of forces acting on connected bodies.	Calculates values and directions of forces acting on an object, where all forces are horizontal or vertical.	Identifies whether the object experiences an overall force.	Identifies forces acting on an object
Momentum and impulse	Analyses practical collisions with the support of calculations of impulse	Applies Newton's 3rd law to analyse collisions.	Calculates change in velocity and/or change in momentum with reference to conservation of momentum and/or impulse experienced.	Describes impulse	Describes momentum
Energy	Analyses energy transfer in situations involving energy dissipated to the enviornment.	Calculates kinematic quantities in cases involving motion of springs.	Calculates kinematic variables in cases involving energy transfer between kinetic and gravitational potential energy.	Distinguishes between elastic and inelastic collisions.	Identifies kinetic, gravitational potential and strain or elastic potential energy

Analyse and evaluate data and investigation methods			
Aspects	**High**	**Medium**	**Low**
use appropriate numbers of significant figures in calculations	able to perform error analysis and expressing final results with the appropriate number of significant figures to reflect the uncertainty in their measurements and calculations, able to make informed decisions about how many significant figures are reasonable in their calculations, based on the precision of the equipment used and the context of the problem.	able to propagate uncertainty by carrying through the number of significant figures correctly in intermediate steps of calculations to maintain precision	able to count the number of significant figures in measurements, both in whole numbers and decimals, able to round numbers to the correct number of significant figures, able to round their answers to problems to the least number of significant figures in the given data.
construct graphs that show the relationship between variables	able to create more complex plots, such as logarithmic graphs, to represent non-linear relationships, able to include uncertainty estimates on the graph, proficient in using data visualisation software like Excel to create professional-looking graphs.	able to draw a line of best fit, able to add error bars to data points to represent the uncertainty in the measurements, able to interpret the graph, identifying trends, patterns, and relationships between variables, includes a title.	able to collect data from experiments and record it accurately, able to label the x-axis (independent variable) and y-axis (dependent variable) appropriately, including units, ble to choose appropriate scales and intervals for the axes to ensure that the data is spread out and visible on the graph.
identify and analyse experimental data qualitatively, handling, where appropriate, concepts of: accuracy, precision, repeatability, reproducibility, resolution and validity of measurements; and errors (random and systematic)	able to evaluate the validity of their measurements by considering whether the experimental setup and procedure align with the intended goals, able to critically analyse and interpret the data, including evaluating the limitations and sources of uncertainty in the experiment.	understand the concepts of repeatability (consistency of measurements within the same experiment) and reproducibility (consistency of measurements when the experiment is repeated by different individuals) understands idea of measurement resolution, which is the smallest incremental change that can be detected by the measuring instrument.	understand the importance of neat and organised data collection, able to distinguish between accuracy (closeness to the accepted value) and precision (reproducibility of measurements).
evaluate investigation methods and possible causes of error and uncertainty, and suggest how precision can be improved, and how uncertainty can be reduced	can perform in-depth analyses of the experiment, considering not only sources of error but also the impact of variations in the experimental conditions, data analysis methods; able to understand how to reduce uncertainty by increasing the number of data points and reducing systematic errors to obtain more reliable and accurate results.	able to critically evaluate the entire experimental design, including identifying potential systematic errors and sources of uncertainty, proficient in quantifying errors and uncertainties, able to propose more substantial changes to the experimental method to reduce errors and uncertainties. This may involve adjusting experimental procedures or improving data collection techniques.	able to assess the basic methodology used in an experiment, identifying the key steps, variables, and equipment involved, can recognise common sources of error, such as measurement errors and instrument limitations, able to propose simple improvements to the experimental setup, such as using more precise instruments or ensuring proper calibration.