

## Internal assessment criteria

### General information

The method of assessment used for internal assessment is criterion-related. That is to say, the method of assessment judges each student in relation to identified assessment criteria and not in relation to the work of other students.

The internal assessment component in all group 4 courses is assessed according to sets of assessment criteria and achievement level descriptors. The internal assessment criteria are for the use of teachers.

- For each assessment criterion, there are a number of descriptors that each describes a specific level of achievement.
- The descriptors concentrate on positive achievement, although for the lower levels failure to achieve may be included in the description.

### Using the internal assessment criteria

Teachers should judge the internal assessment exercise against the descriptors for each criterion. The same internal assessment criteria are used for both SL and HL.

- The aim is to find, for each criterion, the descriptor that conveys most adequately the achievement level attained by the student. The process, therefore, is one of approximation. In the light of any one criterion, a student's work may contain features denoted by a high achievement level descriptor combined with features appropriate to a lower one. A professional judgment should be made in identifying the descriptor that approximates most closely to the work.
- Having scrutinized the work to be assessed, the descriptors for each criterion should be read, starting with level 0, until one is reached that describes an achievement level that the work being assessed does not match as well as the previous level. The work is, therefore, best described by the preceding achievement level descriptor and this level should be recorded. Only whole numbers should be used, not partial points such as fractions or decimals.
- The highest descriptors do not imply faultless performance and moderators and teachers should not hesitate to use the extremes, including zero, if they are appropriate descriptions of the work being assessed.
- Descriptors should not be considered as marks or percentages, although the descriptor levels are ultimately added together to obtain a total. It should not be assumed that there are other arithmetical relationships; for example, a level 2 performance is not necessarily twice as good as a level 1 performance.
- A student who attains a particular achievement level in relation to one criterion will not necessarily attain similar achievement levels in relation to the others. It should not be assumed that the overall assessment of the students will produce any particular distribution of scores.
- The assessment criteria should be available to students at all times.

## Criteria and aspects

There are five assessment criteria that are used to assess the work of both SL and HL students.

- Design—D
- Data collection and processing—DCP
- Conclusion and evaluation—CE
- Manipulative skills—MS
- Personal skills—PS

The first three criteria—design (D), data collection and processing (DCP) and conclusion and evaluation (CE)—are each assessed twice.

Manipulative skills (MS) is assessed summatively over the whole course and the assessment should be based on a wide range of manipulative skills.

Personal skills (PS) is assessed once only and this will be during the group 4 project.

Each of the assessment criteria can be separated into three **aspects** as shown in the following sections. Descriptions are provided to indicate what is expected in order to meet the requirements of a given aspect **completely (c)** and **partially (p)**. A description is also given for circumstances in which the requirements are not satisfied, **not at all (n)**.

A “**complete**” is awarded 2 marks, a “**partial**” 1 mark and a “**not at all**” 0 marks.

The maximum mark for each criterion is 6 (representing three “completes”).

D	× 2 = 12
DCP	× 2 = 12
CE	× 2 = 12
MS	× 1 = 6
PS	× 1 = 6

This makes a total mark out of 48.

The marks for each of the criteria are added together to determine the final mark out of 48 for the IA component. This is then scaled at IBCA to give a total out of 24%.

General regulations and procedures relating to IA can be found in the *Vade Mecum* for the year in which the IA is being submitted.

## Design

Levels/marks	Aspect 1	Aspect 2	Aspect 3
	Defining the problem and selecting variables	Controlling variables	Developing a method for collection of data
<b>Complete/2</b>	Formulates a focused problem/research question and identifies the relevant variables.	Designs a method for the effective control of the variables.	Develops a method that allows for the collection of sufficient relevant data.
<b>Partial/1</b>	Formulates a problem/research question that is incomplete <b>or</b> identifies only some relevant variables.	Designs a method that makes some attempt to control the variables.	Develops a method that allows for the collection of insufficient relevant data.
<b>Not at all/0</b>	Does not identify a problem/research question <b>and</b> does not identify any relevant variables.	Designs a method that does not control the variables.	Develops a method that does not allow for any relevant data to be collected.

## Data collection and processing

Levels/marks	Aspect 1	Aspect 2	Aspect 3
	Recording raw data	Processing raw data	Presenting processed data
<b>Complete/2</b>	Records appropriate quantitative and associated qualitative raw data, including units and uncertainties where relevant.	Processes the quantitative raw data correctly.	Presents processed data appropriately and, where relevant, includes errors and uncertainties.
<b>Partial/1</b>	Records appropriate quantitative and associated qualitative raw data, but with some mistakes or omissions.	Processes quantitative raw data, but with some mistakes and/or omissions.	Presents processed data appropriately, but with some mistakes and/or omissions.
<b>Not at all/0</b>	Does not record any appropriate quantitative raw data <b>or</b> raw data is incomprehensible.	No processing of quantitative raw data is carried out <b>or</b> major mistakes are made in processing.	Presents processed data inappropriately <b>or</b> incomprehensibly.

## Conclusion and evaluation

Levels/marks	Aspect 1	Aspect 2	Aspect 3
	Concluding	Evaluating procedure(s)	Improving the investigation
<b>Complete/2</b>	States a conclusion, with justification, based on a reasonable interpretation of the data.	Evaluates weaknesses and limitations.	Suggests realistic improvements in respect of identified weaknesses and limitations.
<b>Partial/1</b>	States a conclusion based on a reasonable interpretation of the data.	Identifies some weaknesses and limitations, but the evaluation is weak or missing.	Suggests only superficial improvements.
<b>Not at all/0</b>	States no conclusion <b>or</b> the conclusion is based on an unreasonable interpretation of the data.	Identifies irrelevant weaknesses and limitations.	Suggests unrealistic improvements.

## Manipulative skills (assessed summatively)

This criterion addresses objective 5.

Levels/marks	Aspect 1	Aspect 2	Aspect 3
	Following instructions*	Carrying out techniques	Working safely
<b>Complete/2</b>	Follows instructions accurately, adapting to new circumstances (seeking assistance when required).	Competent and methodical in the use of a range of techniques and equipment.	Pays attention to safety issues.
<b>Partial/1</b>	Follows instructions but requires assistance.	Usually competent and methodical in the use of a range of techniques and equipment.	Usually pays attention to safety issues.
<b>Not at all/0</b>	Rarely follows instructions <b>or</b> requires constant supervision.	Rarely competent and methodical in the use of a range of techniques and equipment.	Rarely pays attention to safety issues.

\*Instructions may be in a variety of forms: oral, written worksheets, diagrams, photographs, videos, flow charts, audio tapes, models, computer programs, and so on, and need not originate from the teacher.

See "The group 4 project" section for the personal skills criterion.

## Clarifications of the IA criteria

### Design

#### **Aspect 1: defining the problem and selecting variables**

It is essential that teachers give an open-ended problem to investigate, where there are several independent variables from which a student could choose one that provides a suitable basis for the investigation. This should ensure that a range of plans will be formulated by students and that there is sufficient scope to identify both independent and controlled variables.

Although the general aim of the investigation may be given by the teacher, students must identify a focused problem or specific research question. Commonly, students will do this by modifying the general aim provided and indicating the variable(s) chosen for investigation.

The teacher may suggest the general research question only. Asking students to investigate some physical property of a bouncing ball, where no variables are given, would be an acceptable teacher prompt. This could be focused by the student as follows: "I will investigate the relationship between the rebound height and the drop height of a bouncing ball."

Alternatively, the teacher may suggest the general research question and specify the dependent variable. An example of such a teacher prompt would be to ask the student to investigate the deflection of a cantilever. This could then be focused by the student as follows: "I propose to investigate how the deflection of a cantilever is affected by the load attached to one end." It is not sufficient for the student merely to restate the research question provided by the teacher.

Variables are factors that can be measured and/or controlled. Independent variables are those that are manipulated, and the result of this manipulation leads to the measurement of the dependent variable. A controlled variable is one that should be held constant so as not to obscure the effect of the independent variable on the dependent variable.

The variables need to be explicitly identified by the student as the dependent (measured), independent (manipulated) and controlled variables (constants). Relevant variables are those that can reasonably be expected to affect the outcome. For example, in the investigation of the bouncing ball, the drop height would be the independent variable and the rebound height would be the dependent variable. Controlled variables would include using the same ball and the same surface for all measurements.

Students should **not** be:

- given a focused research question
- told the outcome of the investigation
- told which independent variable to select
- told which variables to hold constant.

### **Aspect 2: controlling variables**

“Control of variables” refers to the manipulation of the independent variable and the attempt to maintain the controlled variables at a constant value. The method should include explicit reference to how the control of variables is achieved. If the control of variables is not practically possible, some effort should be made to monitor the variable(s).

Students should **not** be told:

- which apparatus to select
- the experimental method.

### **Aspect 3: developing a method for collection of data**

The definition of “sufficient relevant data” depends on the context. The planned investigation should anticipate the collection of sufficient data so that the aim or research question can be suitably addressed and an evaluation of the reliability of the data can be made.

The collection of sufficient relevant data usually implies repeating measurements. For example, to find the period of a pendulum, the time for a number of oscillations is measured in order to find the time for one oscillation. Measuring the time for just one oscillation for a given pendulum length would not earn a “complete”. Or, for example, measuring the time for a ball to roll a given distance down an inclined plane can be repeated a number of times and then an average time can be determined.

The data range and the amount of data in that range are also important. For example, in the pendulum experiment, a length range of 10 cm to 100 cm might be used, but measuring the period for only three points within that range would not be appropriate. Similarly, measuring the period for 10 data points in a range from 80 cm to 90 cm would also be inappropriate.

Students should **not** be told:

- how to collect the data
- how much data to collect.

## Data collection and processing

Ideally, students should work on their own when collecting data.

When data collection is carried out in groups, the actual recording and processing of data should be independently undertaken if this criterion is to be assessed.

### **Aspect 1: recording raw data**

Raw data is the actual data measured. This may include associated qualitative data. It is permissible to convert handwritten raw data into word-processed form. The term “quantitative data” refers to numerical measurements of the variables associated with the investigation. Associated qualitative data are considered to be those observations that would enhance the interpretation of results.

Uncertainties are associated with all raw data and an attempt should always be made to quantify uncertainties. For example, when students say there is an uncertainty in a stopwatch measurement because of reaction time, they must estimate the magnitude of the uncertainty. Within tables of quantitative data, columns should be clearly annotated with a heading, units and an indication of the uncertainty of measurement. The uncertainty need not be the same as the manufacturer’s stated precision of the measuring device used. Significant digits in the data and the uncertainty in the data must be consistent.

This applies to all measuring devices, for example, digital meters, stopwatches, and so on. The number of significant digits should reflect the precision of the measurement.

There should be no variation in the precision of raw data. For example, the same number of decimal places should be used. For data derived from processing raw data (for example, means), the level of precision should be consistent with that of the raw data.

Students should **not** be told how to record the raw data. For example, they should not be given a pre-formatted table with any columns, headings, units or uncertainties.

## Aspect 2: processing raw data

Data processing involves, for example, combining and manipulating raw data to determine the value of a physical quantity (such as adding, subtracting, squaring, dividing), and taking the average of several measurements and transforming data into a form suitable for graphical representation. It might be that the data is already in a form suitable for graphical presentation, for example, light absorbance readings plotted against time readings. If the raw data is represented in this way and a best-fit line graph is drawn and the gradient determined, then the raw data has been processed. Plotting raw data (without a graph line) does not constitute processing data.

The recording and processing of data may be shown in one table provided they are clearly distinguishable.

Most processed data will result in the drawing of a graph showing the relationship between the independent and dependent variables.

Students should **not** be told:

- how to process the data
- what quantities to graph/plot.

## Aspect 3: presenting processed data

When data is processed, the uncertainties associated with the data must also be considered. If the data is combined and manipulated to determine the value of a physical quantity (for example, specific heat capacity), then the uncertainties in the data must be propagated (see sub-topic 1.2). Calculating the percentage difference between the measured value and the literature value does not constitute error analysis. The uncertainties associated with the raw data must be taken into account.

Graphs need to have appropriate scales, labelled axes with units, and accurately plotted data points with a suitable best-fit line or curve (not a scattergraph with data-point to data-point connecting lines).

In order to fulfill aspect 3 completely, students should include a treatment of uncertainties and errors with their processed data.

The complete fulfillment of aspect 3 requires the students to:

- include uncertainty bars where significant
- explain where uncertainties are not significant
- draw lines of minimum and maximum gradients
- determine the uncertainty in the best straight-line gradient.

See the treatment of uncertainties and errors in sub-topic 1.2 of this guide.

## Conclusion and evaluation

### **Aspect 1: concluding**

Conclusions that are supported by the data are acceptable even if they appear to contradict accepted theories. However, the conclusion must take into account any systematic or random errors and uncertainties. A percentage error should be compared with the total estimated random error as derived from the propagation of uncertainties.

In justifying their conclusion, students should discuss whether systematic error or further random errors were encountered. The direction of any systematic errors should be appreciated. Analysis may include comparisons of different graphs or descriptions of trends shown in graphs. The explanation should contain observations, trends or patterns revealed by the data.

When measuring an already known and accepted value of a physical quantity, students should draw a conclusion as to their confidence in their result by comparing the experimental value with the textbook or literature value. The literature consulted should be fully referenced.

### **Aspect 2: evaluating procedure(s)**

The design and method of the investigation must be commented upon as well as the quality of the data. The student must not only list the weaknesses but must also appreciate how significant the weaknesses are. Comments about the precision and accuracy of the measurements are relevant here. When evaluating the procedure used, the student should specifically look at the processes, use of equipment and management of time.

### **Aspect 3: improving the investigation**

Suggestions for improvement should be based on the weaknesses and limitations identified in aspect 2. Modifications to the experimental techniques and the data range can be addressed here. The modifications should address issues of precision, accuracy and reproducibility of the results. Students should suggest how to reduce random error, remove systematic error and/or obtain greater control of variables. The modifications proposed should be realistic and clearly specified. It is not sufficient to state generally that more precise equipment should be used.

## Manipulative skills

(This criterion must be assessed summatively.)

### **Aspect 1: following instructions**

Indications of manipulative ability are the amount of assistance required in assembling equipment, the orderliness of carrying out the procedure(s) and the ability to follow the instructions accurately. The adherence to safe working practices should be apparent in all aspects of practical activities.

A wide range of complex tasks should be included in the scheme of work.

### **Aspect 2: carrying out techniques**

It is expected that students will be exposed to a variety of different investigations during the course that enables them to experience a variety of experimental situations.



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A wide range of complex tasks should be included in the scheme of work.

### **Aspect 2: carrying out techniques**

It is expected that students will be exposed to a variety of different investigations during the course that enables them to experience a variety of experimental situations.

### **Aspect 3: working safely**

The student's approach to safety during investigations in the laboratory or in the field must be assessed. Nevertheless, the teacher must not put students in situations of unacceptable risk.

The teacher should judge what is acceptable and legal under local regulations and with the facilities available. See the "Safety" section in this guide under "Guidance and authenticity".

## Personal skills

Note: The personal skills criterion is assessed in the group 4 project only and is to be found in "The group 4 project" section.