Practical Skills Exam Handbook Summary

Practical activity group (PAG)	Techniques/skills covered (minimum)
1 Microscopy	• use of a light microscope at high power and low power, use of a graticule1, 1.2.2 (d) • production of scientific drawings from observations with annotations2, 1.2.2 (e)
2 Dissection	• safe use of instruments for dissection of an animal or plant organ, 1.2.2(j) • use of a light microscope at high power and low power, use of a graticule[1], 1.2.2 (d) • production of scientific drawings from observations with annotations[2], 1.2.2 (e)
3 Sampling techniques	• use of sampling techniques in fieldwork, 1.2.2 (k) • production of scientific drawings from observations with annotations[2], 1.2.2 (e)
4 Rates of enzyme controlled reactions	• use of appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length and pH)[3], 1.2.2 (a) • use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions[4], 1.2.2 (c) • use of ICT such as computer modelling, or data logger to collect data, or use of software to process data[5], 1.2.2 (l)
5 Colorimeter OR potometer	• use of appropriate apparatus to record quantitative measurements, such as a colorimeter or potometer, 1.2.2 (b) • use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions[4], 1.2.2 (c)
6 Chromatography OR electrophoresis	• separation of biological compounds using thin layer / paper chromatography or electrophoresis, 1.2.2 (g)
7 Microbiological techniques	• use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions[4], 1.2.2 (c) • use of microbiological aseptic techniques, including the use of agar plates and broth, 1.2.2 (i)
8 Transport in and out of cells	• use of appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length and pH)[3], 1.2.2 (a) • use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions[4], 1.2.2 (c) • use of ICT such as computer modelling, or data logger to collect data, or use of software to process data[5], 1.2.2 (l)
9 Qualitative testing	• use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions[4], 1.2.2 (c) • use of qualitative reagents to identify biological molecules, 1.2.2 (f)
10 Investigation using a data logger OR computer modelling	• use of ICT such as computer modelling, or data logger to collect data, or use of software to process data[5], 1.2.2 (l) • apply investigative approaches, 1.2.1 (a)
11 Investigation into the measurement of plant or animal responses	• safe and ethical use of organisms to measure plant or animal responses and physiological functions, 1.2.2 (h) • apply investigative approaches, 1.2.1 (a)
12 Research skills	• apply investigative approaches, 1.2.1 (a) • use online and offline research skills, 1.2.1 (h) • correctly cite sources of information, 1.2.1 (i)

[1,2,3,4,5] These techniques/skills may be covered in *any* of the groups indicated.

Useful terms

Accuracy is a measure of the closeness between a test result and the true value. If a test result is accurate, it is in close to the true value.

e.g. The boiling point of pure water – 100 ^{o} is accurate; 99 ^{o} is less accurate; 102 ^{o} is even less accurate.

Anomaly (outlier) is a value in a set of results that is judged not to be part of the normal variation. Look for a result that does not fit the pattern.

e.g. 12 14 17 28 40 22 53 89

Confidence is a qualitative judgement of whether the conclusion is justified by the quality of the evidence.

Error (of measurement) is the difference between an individual measurement and the true value.

Precision is the closeness between independent measurements obtained under the same conditions. It describes the variation you see when you measure the same thing repeatedly with the same device.

e.g. $\pi = 3$ is less precise than $\pi = 3.14$

Repeatability is the precision obtained when results are produced over a short timescale by one person (or the same group) using the same equipment in the same place.

Reproducibility is the precision obtained when measurement results are produced over a wider timescale by different people using equivalent equipment in different (but equivalent) places.

Resolution is the smallest change that can be detected by an instrument.

e.g. The resolution of a regular analogue clock is up to 1s, resolution of a digital stopwatch can be up to 0.01s or 10ms.

Uncertainty is an estimate attached to a measurement which characterises the range of values within which the true value lies. This is normally expressed as 44.0 ± 0.4.

Validity can apply to an individual measurement or a whole investigation. An investigative procedure is valid if it is suitable to answer the question being asked. Validity will be reduced, for example, if no negative control is included in an investigation into the efficacy of a therapeutic drug.

NOTE: **Reliability** will no longer be used. The word 'reliability' is to be avoided because of its ambiguity. For data the terms 'repeatable' and 'reproducible' are clear and therefore better. For conclusions from an experiment, evaluative statements can mention 'confidence' in the quality of the evidence.

Uncertainty

Whenever a measurement is made, there will always be some doubt about the result that has been obtained. An uncertainty in a measurement is an interval that indicates a range within which we are reasonably confident that the true value lies.

- When using an analogue apparatus with a graduated scale, the uncertainty is ± half the smallest graduation. For example, for a burette graduated in divisions of 0.1 cm3, the uncertainty in each measurement is ±0.05 cm3.
- When using digital apparatus, the uncertainty is ± the resolution of the apparatus in each measurement. For example, a two-decimal place balance has an uncertainty of ±0.01 g in each measurement.

Example:

Volumetric or standard flask (Class B)

- A 250 cm3 volumetric flask has an uncertainty of ±0.2 cm3 or 0.08%.

Pipette (Class B)

- A 25 cm3 pipette has an uncertainty of ±0.06 cm3 or 0.24%.

Presentation of results

Table headings

It is expected that all table column (or row) headings will consist of a quantity and a unit. The quantity may be represented by a symbol or written in words. There must be some kind of distinguishing notation between the quantity and the unit.

Example:

T / °C *T (°C)* *T in °C*

Significant figures

The result of a calculation that involves measured quantities cannot be more certain than the least certain of the information that is used. So the result should contain the same number of significant figures as the measurement that has the **smallest** number of significant figures.

Rounding off

When rounding off a number that has more significant figures than are justified, if the last figure is between 5 and 9 inclusive round up; if it is between 0 and 4 inclusive round down. For example, the number 3.5099 rounded to:

4 sig figs is 3.510 *3 sig figs is 3.51* *2 sig figs is 3.5* *1 sig fig is 4*

How do we know the number of significant figures?

If the number 450.13 is rounded to 2 sig figs or 3 sig figs, the result is 450. Therefore, if seen in isolation, it would be impossible to know whether the final zero in 450 is significant (and the value to 3 sig figs) or insignificant (and the value to 2 sig figs). In such cases, standard form should be used and is unambiguous:

- *4.5×10^2 is to 2 sig figs*
- *4.50×10^2 is to 3 sig figs.*

Tables

- All raw data in a single table with ruled lines and border.
- Independent variable (IV) in the first column; dependent variable (DV) in columns to the right
- Processed data (e.g. means, rates, standard deviations) in columns to the far right.
- No calculations in the table, only calculated values.
- Each column headed with informative description (for qualitative data) or physical quantity **and** correct units (for quantitative data); units separated from physical quantity using either brackets or a solidus (slash).
- No units in the body of the table, only in the column headings.
- Raw data recorded to a number of decimal places appropriate to the resolution of the measuring equipment.
- All raw data of the same type recorded to the same number of decimal places.
- Processed data recorded to up to one significant figure more than the raw data.

Graphs

- The graph should be of an appropriate size to make good use of the paper.
- There should be an informative title.
- Error bars are plotted by the addition and subtraction of one standard deviation.
- Range bars show the highest and lowest readings for each set of data.

Bar charts are used when the independent variable is non-numerical – *names of insect species found in a habitat*.

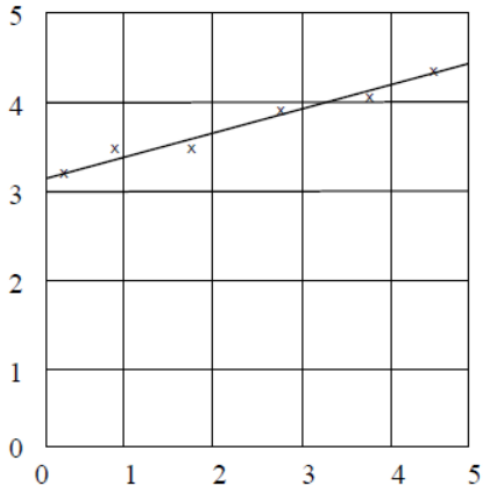
Histograms are frequency diagrams and are used when the independent variable is numerical and the data are continuous – *count of individuals of the flying fox with different wing spans.*

Scattergrams are used when investigating the relationship between two naturally changing (rather than experimentally manipulated) variables – *weight and length of newborns*.

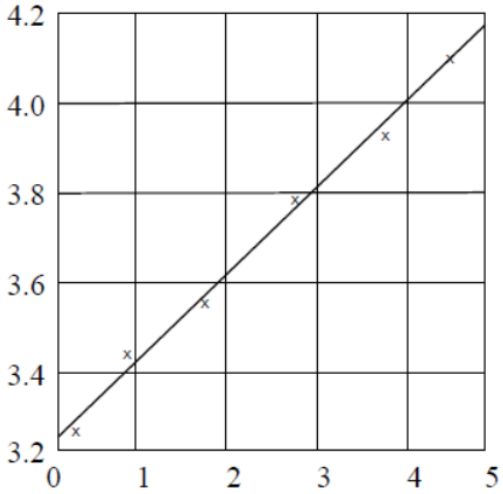
Line graphs are used to show the relationship between an independent variable (usually manipulated by the investigator but there are exceptions, most commonly time) and a dependent variable measured during the investigation – *rate of photosynthesis depending on light intensity*.

Choice of scales

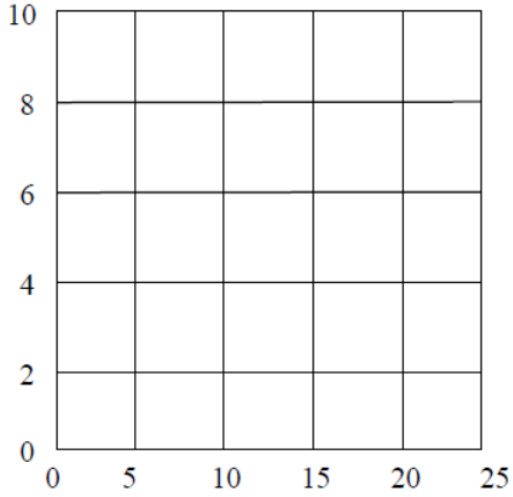
Scales should be chosen so that the plotted points occupy at least half the graph grid in both the *x* and *y* directions.



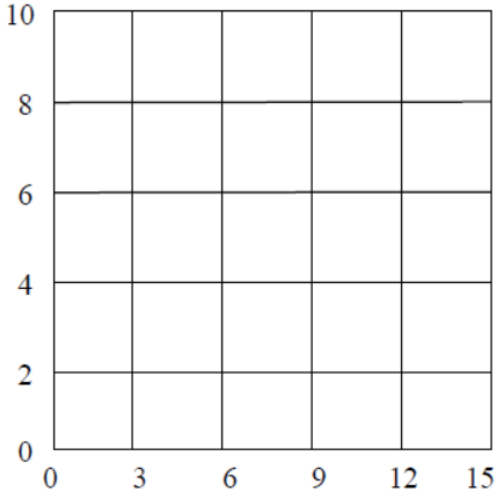
Not acceptable - scale in the *y*-direction is compressed



Acceptable - points fill more than half the graph grid in both the *x* and *y* directions

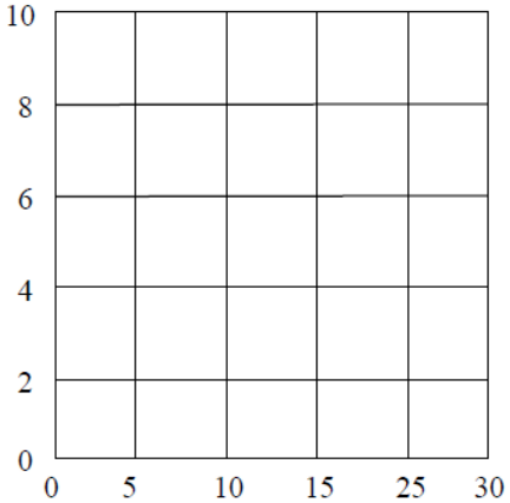


Acceptable scale divisions.

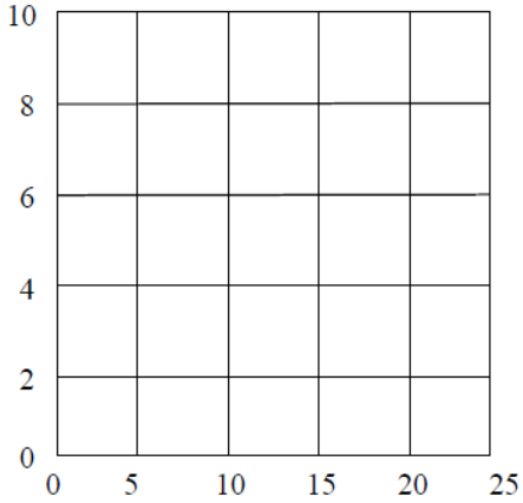


Not acceptable - awkward scale on the *x*-axis.

There should be no 'holes' in the scale.

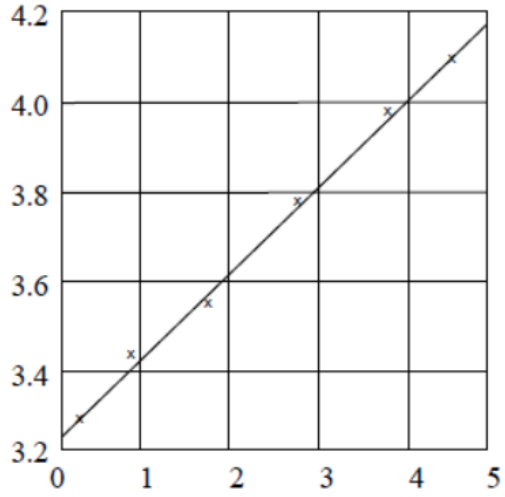


Not acceptable - non-linear scale on the *x*-axis

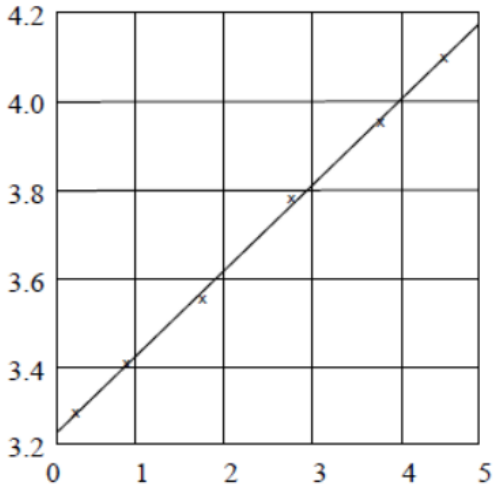


Acceptable - scale labelling is regular

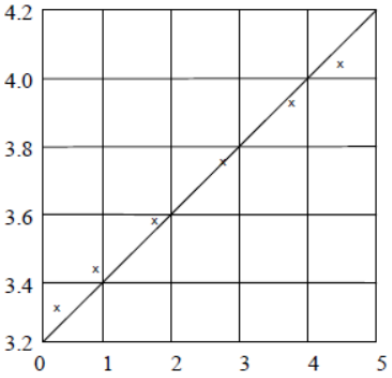
Lines of best fit:



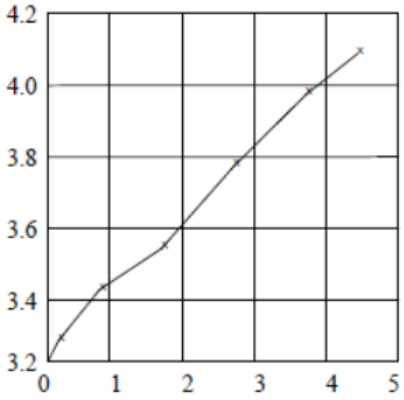
Not acceptable - too many points above the line



Acceptable balance of points about the line

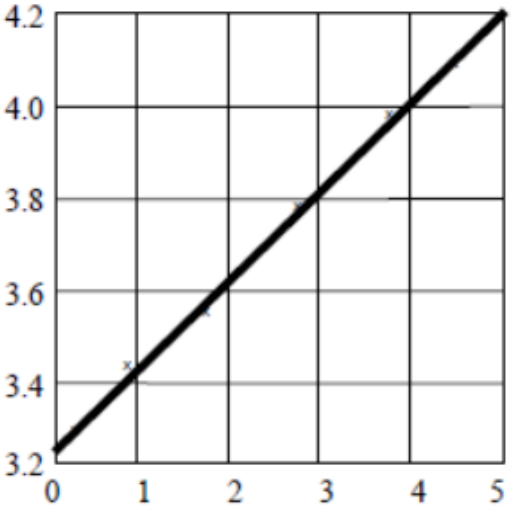


Not acceptable - forced line through the origin (not appropriate in this instance)

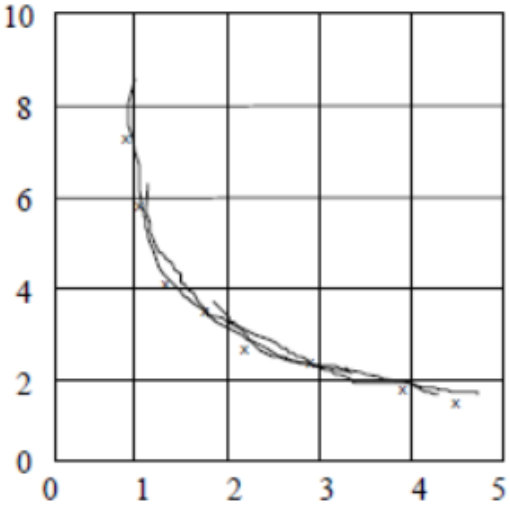


Not acceptable – joining point-to-point even though a clear trend exists.

The line must be thin and clear. Thick/hairy/point-to-point/kinked lines are not credited.



Not acceptable - thick line



Not acceptable - 'hairy' curve