Exercise walk-through

# 3.1
# Planning valid practical investigations

Pearson Edexcel · International A-Level · Physics

# 3.1 Planning valid investigations

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Name: _____ Class: _____ Date: _____ **Total: 26 marks**

**KEY WORDS** valid measurement • independent variable • dependent variable • control variables • resolution • Calibration • zero error

## Objective

Practise the WPH13 skills in planning valid investigations. These are original training

tasks grounded in the specification and reviewed assessment demand.

## 1 Key knowledge and worked examples

A **valid measurement** measures what you intend to measure. A precise timer does not help if it times the wrong event.

Start by naming the **independent variable** that you change and the **dependent variable** that you measure. List **control variables** that could also affect the dependent variable. Say how you will keep each important one steady.

### ■ Turn a description into a usable method

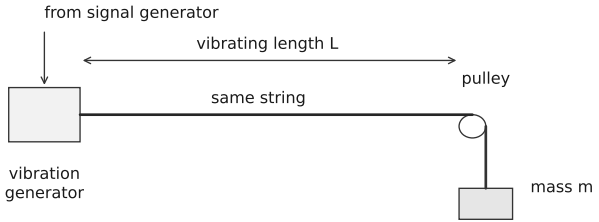
A method needs:

- named apparatus, with a suitable measuring range and **resolution** ;
- an arrangement showing where measurements are taken;
- steps that another student can follow, including the start and end events;
- several independent-variable settings over a useful range;
- repeats where they test stability and estimate variation;
- a calculation or graph that answers the investigation question;
- specific sources of uncertainty and improvements;
- realistic hazards with a practical way to reduce each risk.

Do not write only “take readings” or “use better equipment”. Name the reading, the instrument and what the improvement changes.

### ■ Worked planning example: string frequency and tension

Investigate how fundamental frequency depends on tension in a string.




- Use a vibration generator and signal generator. Pass the string over a pulley to a mass hanger.
- Change hanging mass $m$. With a freely moving pulley, tension is approximately $F_T = mg$.
- Measure vibrating length between the end nodes. Use the same string and keep that length fixed.
- Adjust frequency for the fundamental each time. The same mode is a control, not an optional detail.
- Measure the string's mass and total length to find linear density $\mu$. Keep it unchanged in this investigation.
- Record several tensions and their resonant frequencies. Repeat the tuning near each resonance.

The model for the fundamental is:

$$f = \frac{1}{2L}\sqrt{\frac{F_T}{\mu}} \quad \Rightarrow \quad f^2 = \frac{F_T}{4L^2\mu}$$

A graph of $f^2$ vertically against $F_T$ horizontally should be straight through the origin. A large triangle gives the gradient. Secure the stand and keep your feet away from falling masses. This is stronger than saying "be careful".

### ■ Calibration and zero checks

**Calibration** checks an instrument against known reference values. A **zero error** occurs when it does not read zero at the correct zero condition. Check closed micrometer jaws or an empty balance before measuring.

If a micrometer reads +0.03 mm with its jaws correctly closed, subtract 0.03 mm from each subsequent reading. Repeating the measurement alone does not remove

that offset. A zero check cannot prove that every point on the scale is calibrated correctly.

### ■ Range, spacing and repeats

Choose a range wide enough to reveal the relationship. Several measurements crowded near one setting may give a poor gradient. Use more settings near a turning point if you need to locate a maximum accurately.

Repeats are useful when conditions can be reproduced. They show scatter and help identify unstable readings. However, repeated readings of a discharging cell or a heating wire may drift because the conditions change. Reduce the current, switch off between readings, control temperature or restore conditions. Do not average a drift as though it were random variation.

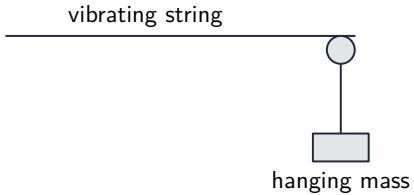
### ■ Control the actual cause

When varying the angle of a lamp above a solar cell, keep lamp–cell distance and lamp output fixed. Control background light, for example with shielding or a darkened room. Keep the cell and its load the same. Otherwise a change in measured power may come from distance, illumination or circuit resistance instead of angle.

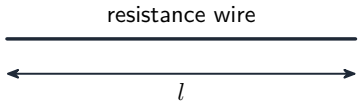
Discuss context using a physical cause. A tracking solar panel can stay closer to normal incidence and collect more energy over a day. Its motor also uses energy and adds cost or maintenance. “Better for the environment” alone does not explain either effect.

# Exercises 2.1·2.2

**2.1** A student varies the hanging mass on a vibrating string and measures its fundamental frequency. Name the independent variable, dependent variable and one control variable.[3]




**2.2** A student measures wire resistance while changing wire length. Explain why a small current, a zero-checked micrometer and secure contacts each improve the investigation.[3]



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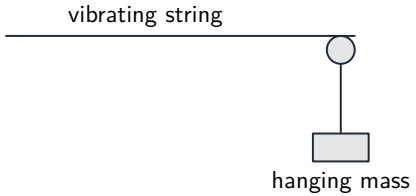


**2.1** Independent: tension, varied through hanging mass. Dependent: fundamental frequency. Keep vibrating length or string linear density fixed.

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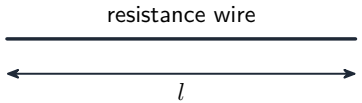
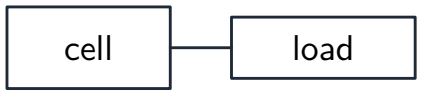



**2.2** Small current limits heating and changing resistivity. The zero check allows a known diameter offset to be corrected. Secure contacts reduce variable contact resistance or intermittent readings.

# Exercise 2.3

**2.3** A student repeats a cell voltage measurement while the cell is supplying a large current. The readings steadily decrease. Explain why averaging alone is not enough and give two practical changes. [3]

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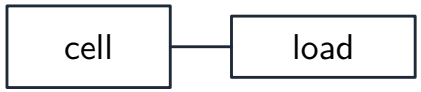
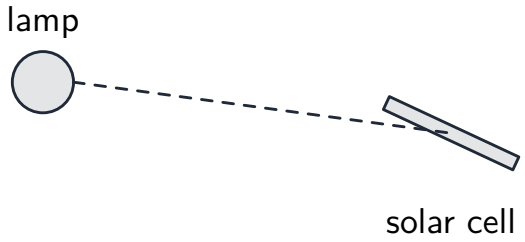



voltage readings decrease

**2.3** The drift indicates changing cell conditions, rather than only random variation. Reduce current/use a larger load resistance. Open the switch between readings and allow conditions to stabilise.

# Exercise 3.1

**3.1** A student changes the angle between light and a solar cell, using a lamp as a model source. Describe three controls with a way to maintain each. Explain how to improve the estimate of the angle giving maximum power. [5]



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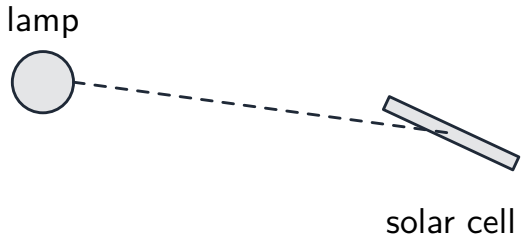


**3.1** Keep lamp–cell distance fixed using a measured constant radius. Keep lamp output fixed using the same supply setting. Keep background light steady with shielding/darkened room, or keep cell load/temperature steady with a stated method. First sample a broad range to find the peak region, then add more closely spaced angle settings around the peak while maintaining controls.

# Exercises 3.2·3.3

**3.2** Plan how to measure the maximum load supported by small beams of equal dimensions but different fibre content. Include load measurement, failure detection, controls, repeatability and safety. [6]

**3.3** Plan an investigation of how string fundamental frequency depends on vibrating length. Include apparatus, resonance identification, controls, graph, interpretation and a safety precaution. [6]

# Exercises 3.2·3.3

**3.2** Plan how to measure the maximum load supported by small beams of equal dimensions but different fibre content. Include load measurement, failure detection, controls, repeatability and safety. [6]

**3.2** Place each beam across supports with the same separation. Add measured masses at the same loading position, converting total supported mass to force using $F = mg$ or reading a suitable force sensor. Increase in small steps near failure and record the highest supported load plus the next failing load as a bracket. Keep dimensions, support arrangement and other preparation conditions fixed. Use several comparable beams per composition because failure destroys a specimen; compare spread/mean rather than reusing a broken beam. Use a shield/eye protection and a tray to catch fragments or falling masses, naming the relevant risk.

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**3.3** Plan an investigation of how string fundamental frequency depends on vibrating length. Include apparatus, resonance identification, controls, graph, interpretation and a safety precaution. [6]

**3.3** Use a vibration generator driven by a signal generator and measure the length between end nodes. Tune to the fundamental at each of several lengths; approach resonance from both sides/repeat. Keep tension and linear density fixed. Plot $f$ against $1/L$; the model predicts a straight line through the origin with gradient $\frac{1}{2}\sqrt{F_T/\mu}$. Secure the stand/masses or protect against a named falling-mass hazard.