

6.2 Implementation and measurement critique

Name: _____ Class: _____ Date: _____

Total: 23 marks

KEY WORDS timing marker • orientation • zero error
• systematic error • random variation

Objective

Practise the WPH16 implementation skills: judge recording resolution, apply timing and length-instrument techniques, correct tables, criticise graphs and circuits, and state component-specific safety. These are original training tasks grounded in the specification and reviewed assessment demand.

1 Key knowledge and worked examples

■ Record what you can actually judge

A recording resolution must match what can honestly be judged. A pendulum's turning point passes quickly and is viewed at an angle, so an amplitude recorded to the nearest 1 mm claims precision the eye cannot deliver; the nearest 5 mm is defensible. The argument works both ways: criticise a resolution that is too fine, and justify a coarse one.

■ Timing oscillations

Measure the time for many oscillations and divide. Reaction-time uncertainty is nearly constant, so a larger measured total gives a smaller percentage uncertainty in the period. Two techniques earn marks in their own right: a **timing marker** at the centre of the oscillation, where the mass moves fastest and the moment of passing is clearest, and starting after several oscillations with a small initial displacement so the motion has settled. Record repeats of the total time, average, then divide.

■ Length instruments, with reasons

Measure a diameter with calipers at several **orientations** and average: a real coil or cylinder is not perfectly round, and averaging attacks **random variation**. Check the zero with the jaws closed and subtract a **zero error**: it shifts every reading the same way, so it is a **systematic error** that repeating cannot remove. Use the micrometer ratchet for consistent contact pressure.

Justifying an instrument is quantitative. A micrometer resolves 0.01 mm, so one reading of 1.21 mm carries an uncertainty of half a division:

$$\text{percentage uncertainty} = \frac{\text{uncertainty}}{\text{value}} \times 100\%$$

$$\text{percentage uncertainty} = \frac{0.005 \text{ mm}}{1.21 \text{ mm}} \times 100\% = 0.4\%$$

The small percentage is the justification.

■ Worked example: criticise this table

Distance / m	Time / s	Time / s	Time / s
0.20	1.1	1.06	1.08
0.40	1.52	1.5	1.54
0.60	1.95	1.91	2.61

- The 1.1 and 1.5 entries do not use the same decimal places as the rest of their column: the timer resolves 0.01 s, so every entry needs two.
- The 2.61 s entry does not fit the pattern of its row (the others cluster near 1.9): identify it as a possible anomaly, check and repeat it – do not silently delete it.
- The heading units are present here; if a column heading lacks its unit, that is a separate fault to name.

■ Criticising a plotted graph

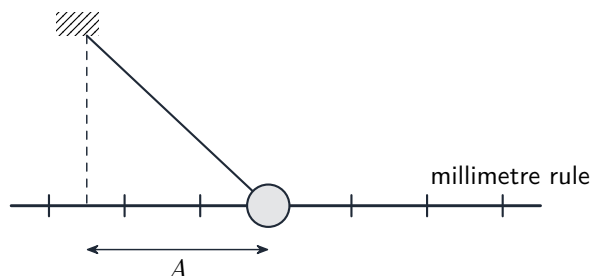
Enough points (at least five), spread over more than half of each axis, on scales that are easy to subdivide (multiples of 3 or 7 are not). Points plotted to within half a small square. A thin continuous best-fit line that balances the scatter – and a check of whether the points are actually straight before drawing one.

■ Capacitor safety and circuit completion

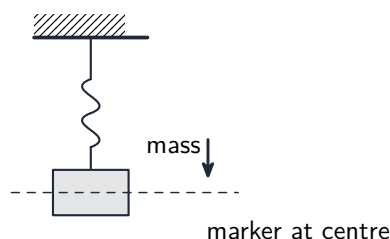
Electrolytic capacitors: connect with the correct polarity; keep the supply below the working voltage; discharge before handling. When a circuit diagram is incomplete, the meter placement rules decide: voltmeter across the named component only, ammeter in series, second components in parallel with the pair they join.

2 Practice

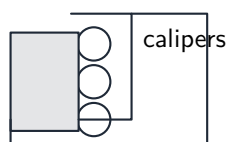
2.1 A student records the amplitude of a damped pendulum every five oscillations, using a rule marked in millimetres placed behind the bob. Give two reasons why recording the amplitude to the nearest 1 mm would not be appropriate. [2]



2.2 The period of a mass-spring system is found by timing 10 oscillations four times: 6.88, 6.93, 6.84, 6.96 s. Calculate the mean period T and state why timing 10 oscillations beats timing one, in terms of percentage uncertainty. [3]



2.3 The internal diameter of a spring's coil is measured with vernier calipers. Describe one technique that improves the accuracy of this measurement and name the type of error it attacks. [2]

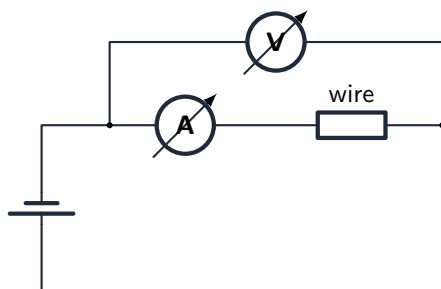


spring coil (internal diameter)

3 Exam-style questions

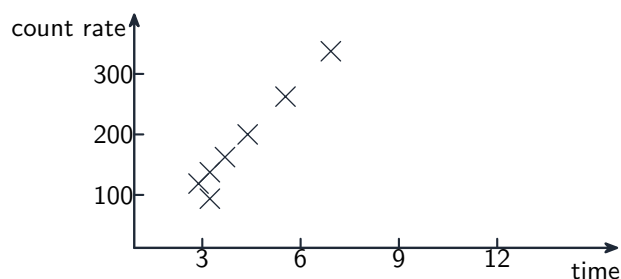
3.1 A student measures the resistance of a thin wire with the circuit shown. The voltmeter is connected across the ammeter **and** the wire together.

Explain why the calculated resistance will not equal the wire's resistance, and describe how the voltmeter should be connected. State one further practical reason the measured value could still be too large. [4]



3.2 A student plots a graph of count rate against time for a decaying source, using the graph below.

Criticise the student's graph. Your answer should identify three separate faults and a practical consequence of one of them. [4]



3.3 A student charges a $470\ \mu\text{F}$ electrolytic capacitor from a $5.0\ \text{V}$ supply through a resistor, using a two-position switch. Position A connects the supply; position B disconnects the supply and leaves the capacitor isolated with a voltmeter across it.

(a) State two safety precautions specific to electrolytic capacitors. [2]

(b) The student records the voltmeter reading immediately after charging and again every $10\ \text{s}$, tabulating 2.51 , 2.5 , 2.42 and $2.6\ \text{V}$. Identify the faults in this recording. [3]

(c) Describe how the circuit should be completed so the voltmeter reads the capacitor alone, and explain one way the timing of the readings could be improved. [3]

