UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2010 question paper

for the guidance of teachers

9702 PHYSICS

9702/51 Paper 5 (Planning, Analysis and Evaluation), maximum raw mark 30

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

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1 **Planning (15 marks)**

Defining the problem (3 marks)

P1 Vary *v* and measure *d*, or *v* is the independent variable and *d* is the dependent variable [1]

P2 Keep mass constant [1]

P3 Keep the wood constant/keep same type of nails [1]

Methods of data collection (5 marks)

M1 Diagram of apparatus showing mass falling onto centre of nail [1]

M2 Change height of falling mass (to change *v*) [1]

M3 Measurement(s) from which *v* can be determined, e.g. measure height fallen; light gate(s) connected to timer/data-logger measuring time, and ticker tape/motion sensor. Do not award stopwatch methods. [1]

M4 Appropriate equation to determine *v* (the velocity of the mass at the instant it hits the nail) [1]

M5 Detail on measuring *d* ; subtract, needle, mark nail, depth gauge [1]

Method of analysis (2 marks)

A1 Plot a graph of log *d* against log *v* [1]

A2 *n* = gradient [1]

Safety considerations (1 mark)

S1 Precaution linked to falling masses, e.g. keep well away/sand trays [1]

Additional detail (4 marks)

D 1/2/3/4 Relevant points might include [4]

1. Method to create a large *d*, e.g. large mass, thin nails, soft wood
2. Use of a guide for falling mass/guide for nail
3. Use of vernier scale to measure *d*
4. Repeat experiment and determine an average
5. Use different part of wood for each test
6. Method to make nail vertical e.g. set square
7. Discussion / preliminary experiment about thin nails going totally into wood
8. lg $d = n$ lg v + lg k

[Total: 15]

2 Analysis, conclusions and evaluation (15 marks)

Part	Mark	Expected Answer	Additional Guidance
(a)	A1	$\frac{1}{2\pi C}$	Allow $\frac{1}{6.28C}$ $\frac{0.159}{C}$
(b)	T1 T2	4.55 — 330 or 333 4.00 — 290 or 294 3.33 — 240 or 238 2.86 — 210 or 208 2.50 — 180 or 179 2.22 — 160 or 161	T1 awarded for 1/*f* column; ignore rounding and sf e.g. allow 4.54 or 4.544 or 4.545 T2 awarded for X_c column – must be values in table
	U1	± 20 (allow ± 17 or 18 or 19), decreasing to ± 10 (allow ± 7)	Allow one significant figure. Do not allow ± 10 for 1st row.
(c) (i)	G1	Six points plotted correctly	Must be within half a small square. Allow ecf from table.
	U2	Error bars in X_c plotted correctly	Check first and last point. Must be accurate within half a small square. All plots must have error bars.
(ii)	G2	Line of best fit	If points are plotted correctly then lower end of line should pass between (2.0, 142) and (2.0, 148) **and** upper end of line should pass between (4.85, 360) and (4.95, 360). Allow ecf from points plotted incorrectly – examiner judgement.
	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through <u>all</u> the error bars.	Line should be clearly labelled or dashed. Should pass from top of top error bar to bottom of bottom error bar **or** bottom of top error bar to top of bottom error bar. Mark scored only if error bars are plotted.
(iii)	C1	Gradient of best-fit line	The triangle used should be at least half the length of the drawn line. Check the read-offs. Work to half a small square. Do not penalise POT.
	U3	Error in gradient	Method of determining absolute error. Difference in worst gradient and gradient.

(d)	C2	$C = 1/(2\pi \times \text{gradient})$ = 0.159/gradient	Gradient must be used correctly. Allow ecf from **(c)(iii)**. Do not penalise POT. If gradient within range given, then *C* in range (2.08 – 2.21) × 10^{6}
	U4	Method of determining error in *C*	Uses worst gradient and finds difference. Allow fractional error methods. Do not check calculation.
	C3	Consistent unit of *C* : **F**	Penalise POT; allow s Ω^{1} or Ω^{1} Hz ^{1}. Should be about 10^{6} F. Unit must be consistent with working.
(e) (i)	C4	0.455 – 0.490 <u>given to 3 sf</u> or 0.46 – 0.49 <u>given to 2 sf</u>	Answer must be in ranges given.
(ii)	U5	Percentage uncertainty in gradient + 10%	Expect to see similar calculation to above. Allow using largest or smallest value methods.

[Total: 15]

Uncertainties in Question 2

(c) (iii) Gradient [E3]

1. Uncertainty = gradient of line of best fit – gradient of worst acceptable line

2. Uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)

(d) *C* [E4]

1. Uncertainty = *C* from gradient – *C* from worst acceptable line

2. $\dfrac{\Delta C}{C} \quad \dfrac{\Delta \text{gradient}}{\text{gradient}}$

(e) τ [E5]

1. Substitution method to find worst acceptable τ using either largest *C* × 242 × 10^3 or smallest *C* × 198 × 10^3

   Percentage uncertainty = $\dfrac{\Delta\tau}{\tau} \times 100$

2. Percentage uncertainty = $\dfrac{\Delta \text{gradient}}{\text{gradient}} \times 100 + 10 = \dfrac{\Delta C}{C} \times 100 + 10$