OCR
Oxford Cambridge and RSA

GCE

Physics B

Unit **H557A/03:** Practical skills in physics

Advanced GCE

Mark Scheme for June 2017

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

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

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations available in RM Assessor

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect response
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3

TE	Transcription error
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
SF	Error in number of significant figures
	Correct response
	Wrong physics or equation

Significant figures:

Usually calculated values are expected to be given to a minimum of 2 sf unless stated otherwise in additional guidance. Candidate's answers which are given to more than 2 sf should round to the value quoted in the markscheme.

Special cases:
3(b)(i) mean change should be to exactly 2 sf to match rest of data in column.
4(a)(iii) and (iv) mean and 2x spread are given to 3 sf in the markscheme otherwise the subsequent calculations become meaningless.
4(b)(i) both values should have the same number of sf (but can be any number of sf).

All marking points are independent unless stated otherwise.

SECTION A

Question			Answer	Marks	Guidance
1	(a)		Immerse in liquid (eg oil/water) with thermometer and means of changing the temperature. Extra detail: e.g. electrically insulate thermistor from water / allow time for thermal equilibrium to be reached at each temp or method of getting below room temperature or stir.	1 1	Change the temperature by heating water or adding hot water/ice or allowing to cool in room.
	(b)		V_{out} rises as temp increases	1	
	(c)	(i)	Appropriate uncertainty bars added to Fig. 1.3 Straight line of best fit drawn within their bars. As straight line can be drawn (results are consistent with V_{out} varying linearly with temperature)	1 1 1	Horizontal bars should be 4 small squares long, vertical bars should be 2 small squares high. Award mark for at majority correctly drawn uncertainty bars. If no error bars drawn, allow line of best fit with even distribution of points either side.
		(ii)	Temperature values written on scale to replace voltage values. Extra detail such as: • Linear relationship makes each scale division the same size • Sensitivity is constant across the whole range • A meaningful comment about the conversion of V to °C.	1 1	Ignore reference to measuring V at different T. Accept change the scale to read temperatures. Examples include: • Subtracting intercept (1.7) from V • Dividing V by gradient (0.05 to 0.07 V $°C^{-1}$) • Multiplying by 1/gradient (14 to 20)

	(d)		**Level 3 (5-6 marks)** Detailed and clearly explained calculations to show that sensitivity and range decreases with both increasing and decreasing values of R_Q. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is clear relevant and substantiated.* **Level 2 (3-4 marks)** Some calculations to compare range or V_{out} of existing set up with increasing R_Q and decreasing R_Q. *There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.* **Level 1 (1-2 marks)** Limited use of graphical information and simple calculations linked to comment on sensitivity/performance/output range. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.	**6**	**Indicative scientific points may include:** **Qualitative comments:** • R_{Th} decreases with increasing temperature. • V_{out} varies depending on the ratio of resistance values. • Sensitivity will decrease with increasing R_Q and decreasing R_Q. • Optimum sensitivity will be when R_Q is about the mid-point of range of R_{Th}. **Calculations from data shown in graphs:** • R_{Th} at low temp (< 5°C) is in range 12 – 16 kΩ. • R_{Th} at high temp (> 30°C) is in range 3 – 4 kΩ. • Range of V_{out} = 3.6 – 1.7 V = 1.9 V over 35°C range. • Sensitivity is approx 0.05 to 0.06 V °C^{-1}. • Calculate R_Q to be in range 7.5 to 8.6 kΩ. **Increasing R_Q:** • V_{out} will increase as R_Q has larger proportion of total R. • Use of potential divider equation to calculate V_{out} with value of R_Q > 9 kΩ at low temp (< 5°C) and high temp(> 30°C). • Show that range of V_{out} is lower than 1.9 V over 35°C range. • Calculation to show that sensitivity is less than 0.05 to 0.06 V °C^{-1} or their value calculated for existing set up. **Decreasing R_Q:** • V_{out} will decrease as R_Q has smaller proportion of total R. • Use of potential divider equation to calculate V_{out} with value of R_Q < 7 kΩ at low temp (< 5°C) and high temp(> 30°C). • Show that range of V_{out} is lower than 1.9 V over 35°C range. • Calculation to show that sensitivity is less than 0.05 to 0.06 V °C^{-1} or value calculated for existing set up.
			Total	**14**	

Question			Answer	Marks	Guidance
2	(a)	(i)	F is proportional to mass.	1	Could be shown as F=mg or calculations. NOT F=ma
			A set (at least 5) of suitable calculations eg: m/x or F/x for each row of table; or Δx for each pair of rows (which have equal Δm = 100g); Find one value for m/x (or F/x) and then use it to predict values for m for each value of x (or vice versa).	1	m/x will give 40.0, 39.2, 40.0, 40.4, 40.0, 40.0 Δx will give 2.6, 2.4, 2.4, 2.6, 2.5 F/x will give 0.392, 0.384, 0.392, 0.396, 0.392, 0.392 Ignore POT as long as they are consistent. Calculated values should be to at least 2sf.
			Δm/Δx is constant approximately/within experimental error/uncertainty	1	If no (or insufficient) calculations then this mark can be awarded for describing a valid test to carry out.
		(ii)	$k = F/x = 0.6 \times 9.8 / 0.15 = 39$ N m^{-1}	1	Accept use of data from any row of the table. 38 N m^{-1} if second row is used.
	(b)	(i)	Two points marked **V** where curve crosses d = 8 cm within half a small square.	1	Any **V** in an incorrect position scores zero
		(ii)	f (= 5.75/4) = 1.4(4) Hz Use of f = n/t with n ≥ 2.	1 1	
		(iii)	Use of f = 1/T and $T = 2\pi\sqrt{(m/k)}$ (to give $m = k / (4\pi^2 f^2)$)	1	Credit use of $m = kT^2/4\pi^2$ and T = 0.7 s. Look for evidence of substitution/evaluation.
			$m = 39/(4\ \pi^2 \times 1.43^2) = 4.8 \times 10^{-1}$ kg	1	Answers should be in range 4.7 to 4.9 x 10^{-1} kg Do not accept calculations involving amplitude of oscillation = 13 cm. Accept reverse argument.

	(c)		**Level 3 (5-6 marks)** ✓✓ Clear procedure/measurements and analysis. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is clear relevant and substantiated.* **Level 2 (3-4 marks)** ✓✓ Some procedure/measurements and analysis *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1-2 marks)** ✓✓ Limited procedure/measurements and/or limited analysis *There is a line of reasoning presented with some structure. The information presented in the most part relevant and supported by some evidence.* **0 marks** *No response or no response worthy of credit.*	**6**	**Indicative scientific points may include:** To gain 2 or more marks, both procedure and analysis statements are needed. **Procedure** Level 3 • Frequency/period of oscillation measured using an oscilloscope attached to signal generator or use data from motion sensor or multimeter. • adjust the frequency in small increments close to the resonant frequency. Level 2 • means of measuring amplitude (use ultrasound motion sensor or ruler adjacent to spring) • repeat and determine an average amplitude at a given frequency • range of frequency either side of resonant frequency Level 1 • vary the frequency using signal generator • measure the amplitude of oscillations • plot a graph of amplitude against frequency **Supporting Analysis** Level 3 • non zero intercept (can be stated or shown on graph) • y-intercept labelled as driving amplitude **or** lower frequencies amplitude = amplitude of driver • higher frequencies the system does not have sufficient freedom to react to driver so amplitude tends to zero. Level 2 • sketch of frequency vs amplitude graph showing peak (or statement) • sketch graph shows frequency tends to zero at higher frequency (or stated in words) • peak labelled **or** maximum amplitude occurs when the natural frequency is equal to the driving frequency. Level 1 • amplitude depends on driven frequency • appreciation that this is an investigation into resonance
			Total	**15**	

Question			Answer	Marks	Guidance
3	(a)	(i)	Minimum of three equally spaced horizontal lines between poles. Arrows on lines N to S	1 1	Lines should be perpendicular to magnet surface and start and touch (or finish close to) surface. Accept curved lines to show edge effects. Ignore field lines outside of the magnet assembly.
		(ii)	Interaction between magnetic field of wire and permanent magnetic field gives rise to a (vertical) force on the wire; which produces a (reaction) force on the magnets (hence balance reading changes)	1 1	 Reference to Newton's third law.
	(b)	(i)	Mean change of both balance readings to 2sf Both values of F	1 1	0.37; 0.47 2sf only – stand alone sf penalty 3.6 or 3.7; 4.6 Allow ecf from incorrectly rounded figures for mean change in balance reading. (3.7 and 4.5)
		(ii)	Largest difference between mean value and max (or min) is 0.03g OR largest half range = 0.02g Either: $\Delta F = \Delta m\ g = \pm 0.3 \times 10^{-3}$ N or $\pm 0.2 \times 10^{-3}$ N depending on previous answer. Or: relative uncertainty in balance reading = $\Delta m/m$ for whichever of the bottom two rows used, to give absolute uncertainty in force = $\pm 0.3 \times 10^{-3}$ N or $\pm 0.2 \times 10^{-3}$ N	1 1	Identification of max variation in data. Allow ecf from incorrect value in bottom row of table. Assuming g has zero uncertainty. Accept multiplying raw data in bottom row by g before finding difference in F values. 0.02/0.47 = 4.3%, 0.02/0.37 = 5.4%, 0.03/0.47 = 6.4% Allow ecf from wrong rounding.
		(iii)	Both points correctly plotted (to within ½ small square) LoBF drawn	1 1	(2.5, 3.6) and (3.0, 0.46) or ecf from table. Line must extend across the range of points shown. No more than 2 small squares vertically from any plotted point.
		(iv)	Gradient calculated from points on line B = gradient/L or B = gradient/0.05 or 5) B = 30 mT	1 1 1	Ignore POT Acceptable range of gradient: $1.4\ \text{mNA}^{-1} < m < 1.7\ \text{mNA}^{-1}$ ecf from their LoBF Correct POT in final answer. Accept values within range: 28 mT < B < 34 mT
			Total	**13**	

SECTION B

Question			Answer	Marks	Guidance
4	a	i	v has largest uncertainty because it is difficult to judge where the image is (perfectly) in focus.	1	Ignore answers relating to % uncertainty. Not just more difficult to measure image distance.
		ii	Range = 0.03(0) m	1	
		iii	mean = 0.401 m Marked correctly on plot by eye – [in the first quarter of the square to the right of the 0.400 grid line]	1 1	Average calculated excluding the two suspected outliers. Allow ecf from incorrect mean. y-position not important.
		iv	Minus x2 spread from mean = **0.371** so 0.330 is an outlier **OR** mean – 0.330 = **0.071** which is greater than 2 x spread so is an outlier. Plus x2 spread from the mean = **0.431** so 0.430 is not an outlier **OR** 0.430 – mean = **0.029** which is less than 2 x spread so not an outlier.	1 1	Allow ecf from mean calculated in (iii) and range calculated in (ii) for both with correct argument. NOT ±0.015
	b	i	m = v/u Both values correct -2.13 and -3.30 Correct sign and consistent number of SF	 1 1	
		ii	Points plotted correctly ± ½ square	1	ECF from (b)i but v should be at 0.48 and 0.66

		iii	Multiply $\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$ by v to get $1 = \frac{v}{u} + \frac{v}{f}$ Substitute in $m = \frac{v}{u}$ to give $1 = m + \frac{v}{f}$ and rearrange (to give $m = 1 - \frac{v}{f}$) OR Rearrange $\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$ to give $\frac{1}{u} = \frac{1}{v} - \frac{1}{f}$ [or $u = \frac{vf}{f-v}$] Substitute into $m = \frac{v}{u} = v\left(\frac{1}{v} - \frac{1}{f}\right) = \frac{v}{v} - \frac{v}{f}$ or m = $\frac{v}{\frac{vf}{f-v}}$ (to give $m = 1 - \frac{v}{f}$)	1 1 [1] [1]	
		iv	Gradient = $\frac{-1}{f}$ Calculation of gradient = -6.67 to give *f* = 0.15 m	1 1	EOR Gradient should be between -6.5 and -6.8. 0.147 m < *f* < 0.154 m. Ignore signs. If correct value for f is given, without evidence of gradient use, then only second marking point awarded.
	c	i	4(.00) D	1	From either intercept.
		ii	Steepest line drawn within error bars Shallowest line drawn within error bars Maximum and minimum powers = intercepts taken from max and min gradient lines drawn Percentage uncertainty = (max value – 4.0) x 100 / 4.0 OR Percentage uncertainty = (4.0 – min value) x 100/ 4.0 OR Percentage uncertainty = ½ (max value – min value) x100 / 4.0	1 1 1 1	Both drawn lines must cross printed line. Accept intercepts from either x or y axes. Correct to ± half a small square from lines drawn by candidate Intercepts can be taken from either line ±0.05D Eg: Minimum = 3.8D Maximum = 4.2D Common values are usually between 5% to 13%
			Total	**18**	

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