



General Certificate of Education

Physics

Investigative Skills Assignment (ISA) P

PHY3T/P10/mark

Written Test

Marking Guidelines

2010 examination – June series

Marking Guidelines Explanatory Notes

The marking guidelines have been devised by a team of experienced examiners. They have tried to anticipate all possible responses worthy of credit. In order to establish consistency it is essential that all centres mark exactly to this scheme.

For ease of use the mark scheme has been presented in tabular form. Concise answers are given in the left-hand column. More detailed explanatory notes for some questions are included in the right-hand column.

Marking of Stage 1 of the ISA – student data and graph – should ideally be completed before the ISA written test to ensure that candidates do not change any data. (Alternatively, centres should take other steps to ensure that candidates do not change any information on their data script/graph). The marking of this section should be annotated with a red tick at the point where the mark has been awarded together with the letter referring to this mark scheme, e.g. ‘✓b.’ **No other comments or feedback should be written on the candidates’ scripts.** The total mark for this section should be written at the top of the paper. This will be transferred to the grid on the front page of the ISA test booklet.

Marking of the ISA test should be done using a red tick to represent each mark awarded. Further annotated comments **can** be added where necessary as an explanation as to why a particular point has been awarded which will greatly aid the moderation process. The total marks for each question should be entered on the grid on the front cover of the ISA booklet and the total mark calculated.

Further guidance and information about the marking guidelines will be given at the teacher support meetings which will be held in the later half of autumn 2010. Assessment Advisers are also allocated to each centre and they can also advise on the marking process.

ISA (P) Refraction

Stage 1	Mark	Additional guidance notes
(a)	1	Column headings can be either in words or standard symbols. Units can be in words or the correct abbreviation. e.g. angle/degrees, $\theta/^\circ$. Alternative acceptable labelling includes angle ($^\circ$).
(b)	1	Correctly indentifying and measuring angle of incidence, θ_1 , and angle of refraction, θ_2 .
(c)	1	Correct calculation of sines.
(d)	1	Minimum of 5 different angles.
(e)	1	Repeat readings of angle of refraction recorded.
(f)	1	Correct calculation of mean values of θ_2 (or $\sin\theta_2$)
(g)	1	Suitably large graph scale (do not award if scale on either axis could have been doubled). Scale must be 'sensible' divisions which can be easily read. The plotted points should occupy at least half of each axis. No mark if angles plotted instead of sines.
(h)	1	Axes must be labelled with quantity. (There should be no unit in this case) Alternative method of labelling axes as in (a) above for table headings. $\sin\theta_2$ (sine of angle of refraction) must be plotted vertically. Allow ecf from (a) if candidates have put a unit for sines and incurred a penalty at that point.

(i)	Most points accurately plotted to within 1 mm (no more than one point $> \pm 1$ mm)	1	This mark is independent of mark (h). i.e. if candidates have used an unsuitable scale they can still achieve marks for accurately plotting the points. Markers should check a proportion of plotted points. 'Most points' would typically allow one incorrect plot in a sample of 6 or 7 plotted points. If only 5 points plotted, they must all be correct.
(j)	Correct line of best fit drawn.	1	The line should be a straight line with approximately an equal number of points on either side of the line. Points which are obviously anomalous should not unduly influence the line. If the plotted points suggest a curve line, the mark can be awarded for a suitable smooth curve. If angles plotted instead of sines, award mark for drawing smooth curve.
	Total	10	

Section A		Mark	Additional guidance notes
1 (a)	$(\pm) 1^\circ$ (or 0.5°). ✓	1	Must be consistent with precision of protractor. Must have unit.
1 (b) (i)	Value based on spread of repeats. ✓ using uncertainty = $\pm (0.5 \times \text{spread})$	1	If repeat readings are identical the uncertainty is the instrument precision. Unit required. No penalty if \pm missing. No significant figure penalty.
1 (b) (ii)	Correctly computed % uncertainty using: % uncertainty = $\frac{\text{uncertainty from (i)} \times 100}{\text{largest angle}} \%$	1	Allow ecf from value from (b) (i) Allow answer quoted to 1 or 2 significant figures only. No penalty if \pm or % symbol missing.

1 (c)	Marking points: <ul style="list-style-type: none"> • spread of repeats > precision of protractor • angle of refraction is always smaller than angle of incidence • width of beam • spread due to range of colours / wavelengths present <p style="text-align: right;">2 marks max ✓✓</p>	2	Do not award mark for ‘light too faint’
1 (d)	Graph is a straight line through origin ✓ $\therefore \sin\theta_2 \propto \sin\theta_1$ / or states directly proportional ✓	2	If candidate’s graph does not go through origin there should be some note to acknowledge this as part of explanation for 1 st mark. (e.g. within limits of experimental error they might conclude close enough to origin to assume direct proportionality). Allow just ‘proportional’.
1 (e)	$\sin\theta_2 = \frac{n_1 \sin\theta_1}{n_2}$ (Compares with $y = mx + c.$) ✓	1	
1 (f)	Gradient = n_1 / n_2 or 1 / (refractive index of glass) ✓	1	Or explained in words: gradient is reciprocal of refractive index of (air to) glass; or gradient = refractive index from glass to air
1 (g)	Draw right-angled triangle with ray and normal ✓ Measure opposite and adjacent sides (or any two sides) and use trig formula ✓ or diagram indicating ray and normal ✓ indicate two sides to measure and use trig formula ✓	2	1 st mark is for making it clear that they use ray and normal in right-angled triangle. 2 nd mark is for indicating two sides to be measured and use of trig formula to find angle. (Trig formula does not need to be stated for this mark).
	Total	11	

Section B		Mark	Additional Guidance Notes
2 (a)	Angle of incidence / θ_1 ✓	1	Allow $\sin\theta_1$
2 (b)	Values of $\sin\theta_2$: 0.719, 0.848, 0.974 ✓ allow 2 or 3 sf	1	Must not be to more significant figures as this would be totally unrealistic given precision of angles.
2 (c)	3 points plotted to ± 1 mm ✓ Correct line of best fit ✓	2	The line should be a straight line with approximately an equal number of points on either side of the line.
2 (d)	Triangle drawn with smallest horizontal side at least 8 cm ✓	1	
	Correct values read from graph ✓	1	
	Correct answer for gradient 1.69 ± 0.03 ✓	1	Allow 2 or 3 significant figures only. No ecf from values read unless gradient falls within stated limits.
2 (e)	Gradient = n = refractive index of glass ✓ $\therefore \sin\theta_c = 1/1.69 = 0.592$ \therefore critical angle = 36° ✓	1	
		1	Allow ecf from incorrect gradient. No significant figure penalty. Unit required.
2 (f)	For angles of incidence > critical angle, there is no refraction ✓		For 1 st mark accept calculation to show for angle of incidence 40° , $\sin > 1$ ✓ or accept a calculation of critical angle showing it is less than 40° .
	Total Internal Reflection occurs ✓	2	
	Total	11	

Question 3			
3 (a)	(i) 19.5° to 20.5° ✓ (ii) $(\sin 19.5^\circ = 0.334; \sin 20.5^\circ = 0.350)$ spread of values = 0.016 ✓	2	Or can be written $\pm 0.5^\circ$. Must have unit. Allow answer written as ± 0.008
3 (b)	% uncertainty = $0.008 \times 100/0.342 = \pm 2.3\%$	1	No penalty for missing \pm sign or %. No significant figure penalty. Mark is for answer only.
3 (c)	For violet light, $\sin \theta_2 = \sin 20^\circ \times 1.80 = 0.616$ ✓ (giving $\theta_2 = 38.0^\circ$ as stated)	1	No penalty if unit is missing in final statement.
3 (d)	This is a change of 2.5° , ✓ so will be measurable if protractor precision is 0.5° . ✓	2	No unit penalty if figures referred to without unit.
	Total	6	
Question 4			
4 (a)	Monochromatic light / light single wavelength ✓ Greater intensity / well-defined beam ✓	2	
4 (b)	Either Safety issue: reflection of lasers from other surfaces potentially dangerous / don't look down beam Or Only measures refractive index for one wavelength / only measures refractive index for laser wavelength 1 mark max ✓	1	Any other alternatively phrased explanation relating to dangers using laser or precautions which need to be taken.
	Total	3	
	Total	31	