Teacher Resource Bank

GCE Physics B: Physics in Context

Sample AS ISA: Equilibrium of Forces

- Mark Scheme

AQA Physics Sample ISA Mark Scheme – Equilibrium of Forces

Stage 1			
(a)	Table with column headings showing all recorded results for mass and angle measurements.	**1**	Column headings can be either in words or standard symbols.
(b)	**All** units correct in column headings.	**1**	Units can be in words or the correct abbreviation, e.g. mass/kilograms, m/kg. Alternative acceptable labelling includes mass (g), mass in g etc
(c)	Decimal places correct for all readings, compatible with precision of instruments used.	**1**	For example, masses quoted to nearest g, but if checked on balance this would depend on balance resolution. Angles quoted to nearest degree or half degree.
(d)	Minimum of **seven** readings.	**1**	At least seven different masses with corresponding angles.
(e)	At least one repeat reading for each angle with mean calculated.	**1**	Markers should check a proportion of the calculations to satisfy themselves that the candidate is correctly computing mean values. The mark may still be awarded if there is an 'occasional error' in calculations (typically allow one error in set of seven results).
(f)	Tabulated values of $\tan \theta$.	**1**	
(g)	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.	**1**	The plotted points should occupy at least half of each axis.
(h)	Correctly labelled axes with units.	**1**	Both axes labelled with quantity and unit. Words or symbols may be used for physical quantities and units, e.g. mass/kilograms, m/kg. Acceptable alternative labelling includes m (kg), mass (kg), mass in kg.
(i)	Most points accurately plotted to within 1 mm (no more than one point > ± 1 mm).	**1**	This mark is independent of mark (g), 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.
(j)	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.
	Total	**10**	

Section A			
Question 1			
(a)	Angle of string AB to vertical, θ.	**1**	Allow just 'angle'.
(b)	Range of masses selected to give a suitable range of angles ✓ Acknowledges that minimum mass will give small angle with large % uncertainty/with large masses when angle gets close to 90° uncertainty in tanθ is very large ✓	**2**	Any comment recognising that the range of masses used need to give a range of different, measurable angles. The second mark is for explaining the problems when either the mass used is too small or too large.
(c)	Uncertainty in angle quoted as ± 1° (or ± 0.5°) ✓ uncertainty calculated correctly from % uncertainty = $\frac{\text{uncertainty} \times 100}{\text{angle for largest mass}}$ ✓ allow e.c.f.	**2**	E.g. uncertainty ± 1°, largest mass, angle 60°. % uncertainty = 1/60 × 100 % = 1.6 % No significant figure penalty.
(d) (i) (ii)	Use of plumbline/ protractor between plumbline and string ✓ Use of spirit level/ measure at each end of string to bench, bench checked with spirit level ✓	**2**	Allow 'assume bench is horizontal and use set square from bench for vertical and protractor between this and string'. Do not allow a second mark for method based on assumption that bench is horizontal.
(e)	Tanθ is directly proportional to m_K ✓	**1**	Allow 'proportional' instead of 'directly proportional'.
(f) (i) (ii)	Equation becomes: $tan\theta = \frac{m_k}{m_u}$ ✓ Gradient = $\frac{1}{m_u}$ ✓	**2**	
	Total	**10**	

Section B			
Question 2			
(a)	All 3 correct *tanθ* values: 1.07, 1.26, 1.42 **or** 1.069, 1.257, 1.420.	**1**	All three values must have consistent significant figures.
(b)	All 3 points plotted to nearest mm ✓✓ **Or** any 2 points plotted to nearest mm 1 mark. Line of best fit drawn through points ✓	**3**	
(c)	Triangle drawn with smallest horizontal side at least 8 cm ✓ Correct values read from graph ✓ Correct answer for gradient 17.8 ± 0.2 (kg^{-1}) ✓	**3**	Allow, 17.8 ± 0.2 kg^{-1} or calculation based on e.c.f. from incorrectly read scale value(s); **no unit penalty.**
(d)	1/gradient = 0.056 kg or 56 g. Allow e.c.f. from incorrect gradient (no sig fig penalty).	**1**	Unit is required for mark.
(e)	% difference = (0.001/0.055) × 100 % = 1.8 % allow e.c.f. from incorrect value from Q2(d) ✓ Relevant comment that explains the small % difference; uncertainty in *x* and *y* is small/points all close to the line on the graph/no systematic error ✓	**2**	A very slight difference in gradient will give a significant % difference, this is obviously still correct. No mark for just stating that the value is close to or equal to the accepted value without an additional relevant comment.
	Total	**10**	

Question 3			
(a)	% uncertainty in x = 1/664 × 100 % = 0.15 % ✓ % uncertainty in y = 1/746 × 100 % = 0.13 % ✓	**2**	Allow % uncertainty quoted to 1 s.f. since these are only estimates, i.e. 0.2% and 0.1%. Question is specified as % uncertainty, hence allow marks if % symbol omitted.
(b)	% uncertainty in $tan\theta$ = 0.15 + 0.13 = 0.28 % allow e.c.f. from (a)	**1**	Allow 0.3% (allow with % symbol omitted).
(c)	Reference to % uncertainty data from Q1(c) and Q3(b) ✓ Conclude that measuring lengths is more precise method ✓ Alternative relevant comments for a 2nd mark; ensuring measurement of x and y to ± 1 mm would be difficult – aligning string, ensuring distances exactly horizontal and vertical etc/using a protractor is easier and quicker ✓	**max 2**	Allow e.c.f. from 1 (c) if it suggests that direct measurement of angle is more precise (n.b. it is not strictly true to directly compare % uncertainty in θ with % uncertainty in $tan\theta$, but the figures do provide some evidence as to the best method - calculation of % uncertainty in *$tan\theta$ directly from % uncertainty in θ* is beyond the scope of AS level). (As a general guide to marking in this type of question, candidates should make an appropriate statement (1 mark) justified by reference to numerical evidence, possibly from data/calculations in previous questions).
(d)	Possible sources of systematic error; String BC not horizontal due to not checking or faulty spirit level ✓ Angle θ not measured from true vertical/ plumb bob misaligned ✓	**2**	Do not allow misreading protractor or ruler. Allow also; - friction at pulley (although this may vary with different loads) - worn end of ruler.
	Total	**7**	

Question 4			
	Any **four** of the following points • suggestion to model the situation in the laboratory by representing soldier as a weight suspended from horizontal string • sensible method of measuring appropriate angle e.g. use large protractor attached to suspended weight (soldier) or supports to measure angle between either wire and vertical • sensible method of measuring tension e.g. insert spring balance/strain gauge between wire and harness • suggestion to take a set of readings of angle and corresponding tension at positions along the wire • keep suspended weight (soldier) constant • checking the wire has not stretched • plot graph of angle (or some function of angle) versus tension • correct theoretical analysis of situation to try to deduce a relationship between tension and angle.	**max 4**	Any other valid point which describes a good alternative method of measuring angle or tension. **Or** Which describes a valid method of reducing error. **1 mark only** - other 3 marks must come from the listed marking points.
	Total	**4**	