Teacher Resource Bank

GCE Physics A

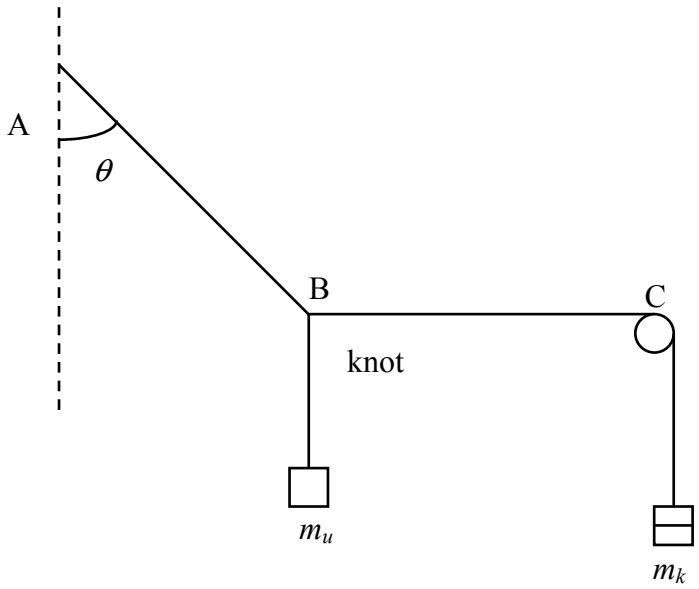
Sample AS ISA: Equilibrium of Forces

- Question Paper

AQA Physics Sample ISA – Equilibrium of Forces

Centre Instructions

In this ISA, candidates will be investigating the equilibrium of forces acting in different directions. The diagram below illustrates the arrangement.



Candidates will require:

- an object of unknown mass labelled m_u (e.g. a rubber bung of mass ≈ 50 g with a string attached is suitable)
- a set of 10 g slotted masses with weight hanger
- a piece of string, pulley which can be fixed to a retort stand using a boss and/or clamp
- a second stand with clap and boss
- a protractor
- access to a plumb line (could be shared by several candidates)
- access to a spirit level (could be shared by several candidates).

Candidates will be expected to set up the apparatus as shown, with a string AB at an angle θ to the vertical attached to a knot B from which is suspended the fixed unknown mass m_{u}, and continuing (BC) horizontally to a pulley with the known 10 g slotted masses m_{k} hanging from the other end.

Information for centres

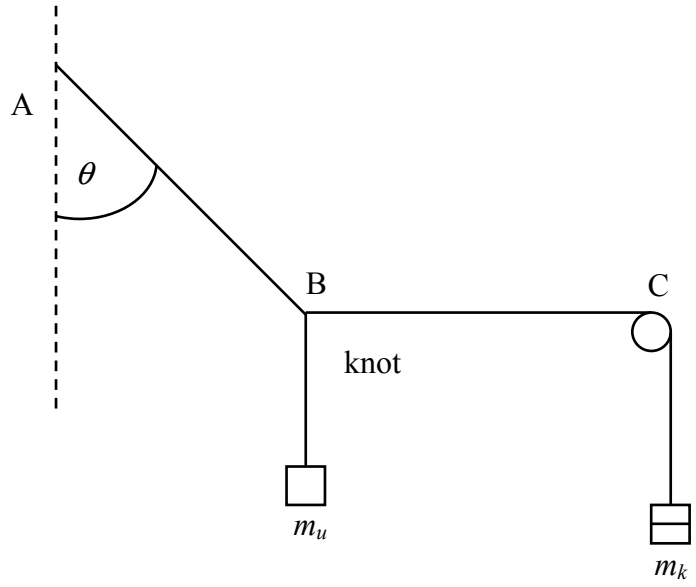
Candidates can be told approximately one week before undertaking Stage 1 of the ISA that the investigation will be about the equilibrium of forces and resolving.

Stage 2 of the ISA (the written tests; Section A & B) should be given as soon as possible after the practical investigation.

Task Sheet

Stage 1: Investigation

You are going to investigate the variation in the angle at which the tension in a string must act to produce equilibrium between the forces produced by the weights of 2 masses, a known mass m_k and an unknown mass m_u.



- Set up the apparatus as shown in the diagram. Write down how you are going to measure the angle to the vertical and how you will check that the string BC is horizontal.
- Select a value for the known mass, adjust the position of the pulley so that string BC is horizontal, and measure the angle θ, (you may need to move the position of the stand supporting the pulley and/or adjust the height of the pulley).
- Take a range of readings of the known mass and the angle. You should take repeat readings if you think this is appropriate.
- Present your results in a table, including one column for tabulating values of $\tan\theta$.
- Plot a graph of $\tan\theta$ against the known mass, m_k.
- Write down the precision of the protractor you used, and the resolution of the balance used to check the known masses.

At the end of the investigation, please hand in all your written work, including the graph, to the supervisor.

This documentation will be required for Stage 2 of the ISA. Please ensure that you have entered your centre details, candidate number and name on all the sheets you have completed.

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Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

Leave blank

General Certificate of Education

Advanced Subsidiary Examination

PHYSICS
Investigative and Practical Skills in AS Physics

Sample Unit 3 ISA
Written Test

For Examiner's Use		
		Mark
Stage 1		
Section A	**1**	
Section B	**2**	
	3	
	4	
Total (Sec A)		
Total (Sec B)		
TOTAL		
Examiner's Initials		

For this paper you must have:
- a calculator
- a ruler
- a protractor
- your completed documentation from Stage 1.

Time allowed: 1 hour

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the spaces provided.
- Attach your completed documentation from Stage 1 to this book before handing it to the invigilator at the end of the examination.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for the questions are shown in brackets.
- The maximum mark for this paper and the practical task is 41.

SECTION A

Answer **all** questions in the spaces provided.
You should refer to your documentation from Stage 1 as necessary.

1 (a) What is the *dependent variable* in the experiment?

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(1 mark)

1 (b) Explain what factors should be considered in determining the range of known masses to be used in this experiment.

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(2 marks)

1 (c) Calculate the % uncertainty in the angle for the **largest** value of known mass.

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(2 marks)

1 (d) Explain

1 (d) (i) how you measured the angle from the vertical,

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1 (d) (ii) how you checked that the string BC was horizontal.

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(2 marks)

1 (e) By reference to your graph, explain what you conclude about the relationship between $tan\theta$ and m_k.

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(1 mark)

1 (f) Theory shows that for this experiment,

$$m_u \, tan\theta = m_k.$$

1 (f) (i) Rearrange the equation into the standard form for the equation of a straight line

$$y = mx + c.$$

.....

1 (f) (ii) What physical quantity does the gradient of your graph represent?

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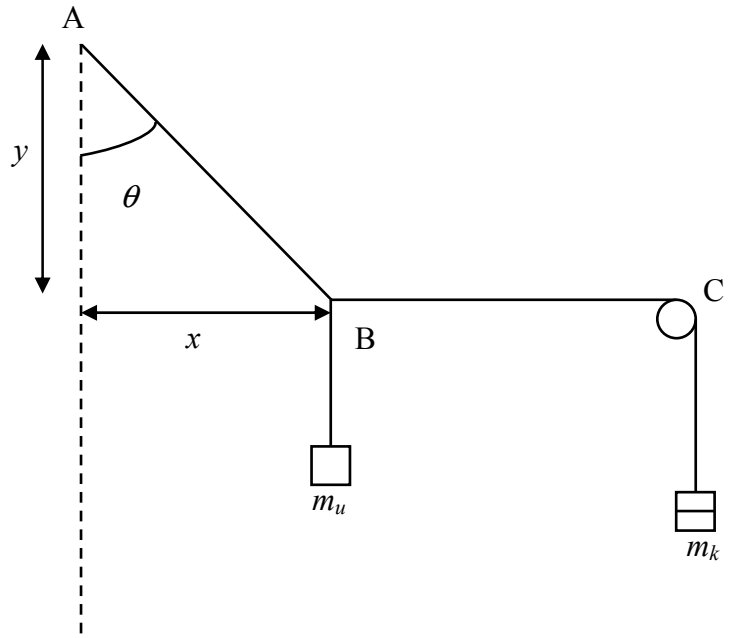
(2 marks)

(Total 10 marks)

SECTION B

Answer **all** questions in the spaces provided.

2 In a similar experiment, the angle θ was found by measuring the horizontal and vertical distances x and y, from the knot B to the point of suspension A. The arrangement is shown below.



The results are recorded in the table below.

m_k/kg	x/mm ± 1 mm	y/mm ± 1 mm	$tan\theta$
0.0100	176	984	0.179
0.0200	334	942	0.355
0.0300	474	880	0.539
0.0400	581	814	0.714
0.0500	664	746	0.890
0.0600	730	683	
0.0700	782	622	
0.0800	818	576	

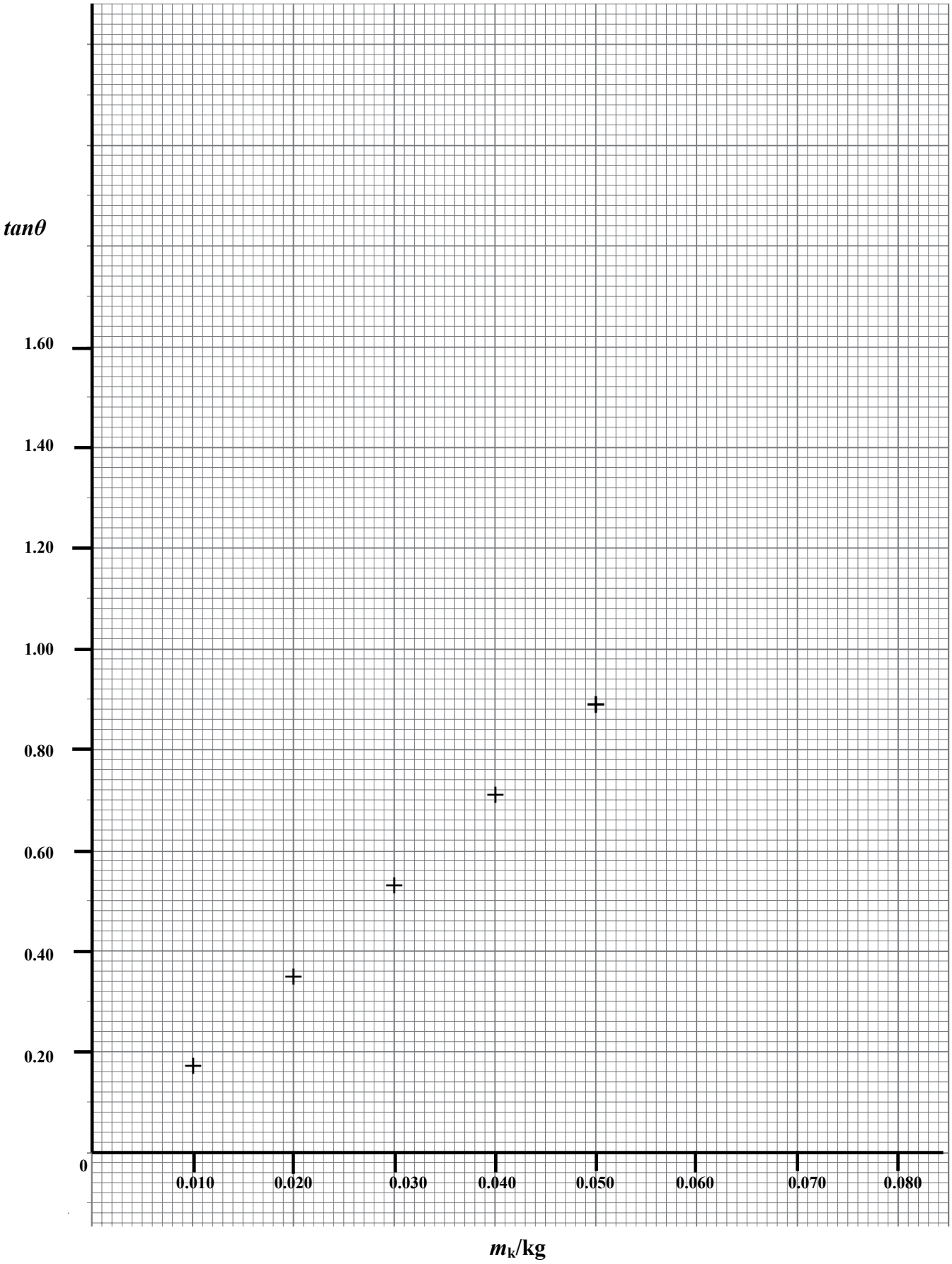
2 (a) Complete the values of $tan\theta$ in the table.

(1 mark)

2 (b) Plot the final three points on the graph and draw the line of best fit.

(3 marks)

Graph of $tan\theta$ versus m_k for forces in equilibrium



2 (c) Calculate the gradient of the line.

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(3 marks)

2 (d) Calculate the reciprocal of the gradient and state its unit.

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(1 mark)

2 (e) In this experiment the directly measured value of the unknown mass was 0.0550 kg. Calculate the % difference between this and the value calculated from part 2 (d). By reference to the experimental data, comment on this difference.

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(2 marks)

(Total 10 marks)

3 (a) For the 0.0500 kg reading in the table, calculate the % uncertainties in x and y.

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(2 marks)

3 (b) By reference to part 3 (a) above, calculate the % uncertainty in $tan\theta$.

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(1 mark)

3 (c) Compare this method of measuring the angle from x and y with the method you used in your own experiment using a protractor. You may wish to refer to the values of uncertainties calculated.

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(2 marks)

3 (d) What are possible sources of systematic error in the experiment?

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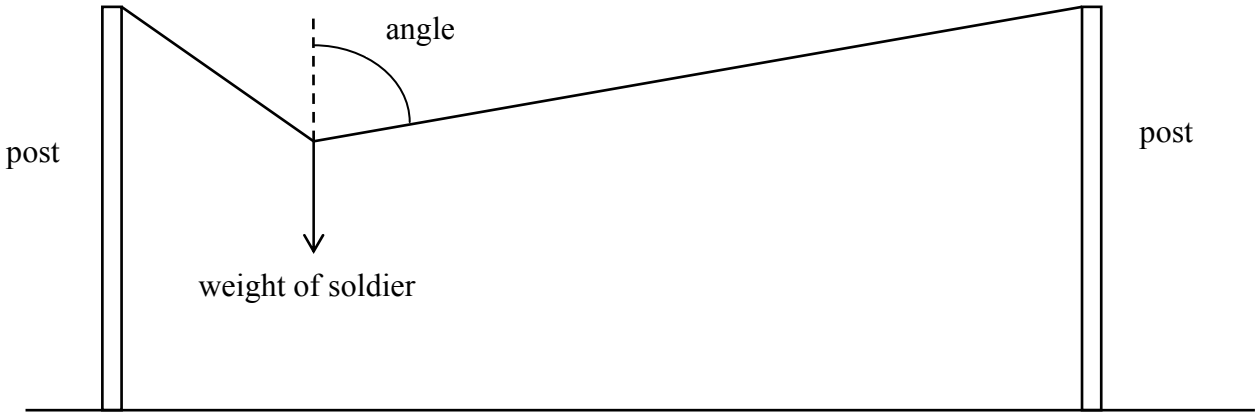
(2 marks)

(Total 7 marks)

4 As part of an assault course, a long wire is suspended between two posts on the same horizontal level. A soldier has to move along the wire, hanging below the wire. As a result, the angle of the wire to the vertical at the point where the soldier is hanging, varies as the soldier moves along the wire. Suggest how you could investigate the variation of this angle and the resulting variation in the tension in the wire.



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(4 marks)

(Total 4 marks)