General Certificate of Education
Advanced Subsidiary Examination
June 2009

Physics (Specifications A and B) PHA3/B3/XTN

Unit 3 Investigative and Practical Skills in AS Physics
Externally Marked Practical Assignment (EMPA)

Instructions to Supervisors Confidential

To be given immediately to the teacher(s) responsible for GCE Physics

Open on receipt

- **These instructions are provided to enable centres to make appropriate arrangements for the Unit 3 Externally Marked Practical Assignment (EMPA)**
- **It is the responsibility of the Examinations Officer to ensure that these *Instructions to Supervisors* are given immediately to the Supervisor of the practical examination.**

INSTRUCTIONS TO THE SUPERVISOR OF THE EXTERNALLY MARKED PRACTICAL EXAMINATION

General

Security/confidentiality

The instructions and details of the EMPA materials are strictly confidential. In no circumstances should information concerning apparatus or materials be given before the examination to a candidate or other unauthorised person.

The EMPA supplied by AQA at AS and at A2 for a given academic year must only be used in that academic year. It may be used for practice purposes in other years.

Using information for any purpose beyond that permitted in this document is potentially malpractice. Guidance on malpractice is contained in the JCQ document Suspected Malpractice in Examinations and Assessments: Policies and Procedures.

The Examinations Officer should give copies of the Teacher Notes (PHAB3/X/TN and/or PHAB6/X/TN) to the Head of Department upon receipt.

Material from AQA

For each EMPA, AQA will provide:

- Instructions to Supervisors
- Section A Task Sheets 1 and Task Sheet 2
- Section B EMPA written test papers

Preparation/Centre responsibility

Practical work should be carried out after candidates have acquired the necessary skills and after teaching the appropriate sections of the specification. Candidates should also be familiar with the apparatus they will use.

It is the responsibility of the centre to ensure that the investigation works with the materials provided to the candidates.

The assessment and management of risks are the responsibility of the centre.

Practical Skills Verification (PSV)

Candidates must undertake the 5 practical activities specified, in order for them to demonstrate in the EMPA that they can use apparatus appropriate to the teaching of Physics at this level. In doing so, candidates will be familiar with the equipment and skills they will use in the EMPA. The teacher must confirm on the Candidate Record Form that this requirement has been met.

Section A: Task 1 and Task 2

- Candidates should work individually and be supervised throughout. They should not discuss their work with other students during this time.
- The work can be carried out in normal timetabled lessons and at a time convenient to the centre. Teachers will be in the best position to judge how many sessions are appropriate for candidates in their own centre.
- The candidates' work must be handed to the teacher at the end of each practical session and kept securely until the next stage of assessment.
- There is no specified time limit for these tasks, however candidates should be informed by the Supervisor of the expected overall timescale and timetable arrangements for the undertaking of the tasks and the organisation of the tasks in the laboratory. Candidates must also be instructed that all readings must be entered in the question paper/answer book provided and all working must be shown. Scrap paper must not be used.

Sharing equipment / working in groups

Candidates are expected to work individually. Where resources mean that equipment has to be shared, the teachers should ensure that the candidates complete the tasks individually. For example, they should take turns with the equipment in order to collect and process their own data. Whatever arrangement is adopted, enough apparatus and materials must be prepared to ensure that in the case of failure of a set of apparatus, a substitute is available so that the candidate does not lose time.

Centres may provide sufficient sets of apparatus for half their candidates to work on Section A Task 1, Question 1 while the other half work on Question 2. Under strict supervision, the groups of candidates change over. It will be necessary to allow a short period of time whilst the change-over takes place. During this time the apparatus should be returned to its original state, ready for use by the next group of candidates.

Practical sessions

The apparatus and materials for each candidate must be arranged neatly, and ready to use, on the laboratory bench. No attempt should be made to connect together any parts or wire up any electrical circuits except when specifically stated in these Instructions.

If a candidate is unable to perform any experiment, or is performing an experiment incorrectly, the Supervisor is expected to give the minimum help required to enable the candidate to proceed. In this instance, the Supervisor's Report should be completed with the candidate's name and number, reporting to the Examiner the extent of the help given. No help should be given with the analysis of the experimental data.

It is not the wish of the Examiner that a candidate should waste time because of, for example, an incorrect electrical connection. The Examiner wishes to test the candidate's ability to perform an experiment and carry out the subsequent analysis. Any failure in the apparatus should also be reported to the Examiner.

Section B: EMPA written test

- The Section B EMPA written test should be taken as soon as convenient after completion of the Section A tasks.
- The test should be carried out under controlled conditions and must be completed in a single uninterrupted session.
- Candidates should be provided with their completed copy of Section A Task 2 question paper/ answer booklet in addition to the test paper (Section B).
- The test duration will be 1 hour 15 minutes.

Administration

Candidates must not bring any paper-based materials into any session or take any assessment materials away at the end of a session. Mobile phones are not allowed.

Modifications

The equipment requirements for the tasks will be indicated on the Teachers' Notes. In some cases, the equipment may be specifically listed (e.g. a specific value of a resistor), others may be more open ended. Where details are specific, centres may wish to modify this in order to take account of the conditions and equipment available in the centre. Any modifications must be discussed with the Assessment Adviser or AQA before candidates undertake the tasks. Written confirmation of modifications made to the tasks must be specified on the Supervisor's Report.

Absent candidates

Candidates absent for the practical work (Section A tasks) should be given an opportunity to carry out the tasks before they sit the EMPA written test. This may be with another group or at a different time. In extreme circumstances, when such arrangements are not possible the teacher can supply a candidate with class data. In this case, there will be no evidence for Task 1 or Task 2, so no marks can be awarded for Section A.

Redrafting

Candidates may make only one attempt at a particular EMPA and redrafting is **not** permitted at any stage during the EMPA.

The Supervisor's Report

The Supervisor is required to report details as below concerning the experiment, apparatus or materials to the Examiner on the Supervisor's Report located at the end of this document. This Supervisor's Report must be attached to the topmost script before despatch to the Examiner.

Details must be given on the Supervisor's Report if the apparatus or materials provided differ from that detailed in this document. Where specific information or data about apparatus or materials is requested in these instructions, it is important that it is given accurately. In some cases it may represent the only means available to the Examiner of assessing the accuracy of a candidate's work.

Security of assignments

Candidates' scripts **and**, where appropriate, the question papers at each stage of the EMPA should be collected at the end of each practical exercise. Under no circumstances should candidates be permitted to remove question papers from the examination room.

At the end of each task, candidates' scripts must be stored securely until the next stage of assessment. Scripts for all the exercises (tasks/Sections) should be collated.

Completed EMPAs should be treated like examination papers and kept under secure conditions until sent to the Examiner.

Submitting materials to the AQA Examiner

All materials must be submitted to the AQA examiner by the specified deadline issued by AQA.
A treasury tag should be used to secure each candidate's material before despatch to the Examiner.
For each candidate the following materials must be submitted in the following order:

- a Candidate Record Form
- Task 1
- Task 2
- EMPA written test.

In addition each centre must provide:

- a *Centre Declaration Sheet*
- the *Supervisor's Report*.

Section A Task 1

Candidates are to measure the volume of a rubber stopper to which a steel wire loop has been fixed, by two different methods.

Question 1

Apparatus

- ❑ rubber stopper, type 23, e.g. Fisher Scientific FB52033 or Scientific and Chemical RTS 01020
- ❑ large paper clip, length about 50 mm; this can be used to fashion the steel wire loop which is pushed into the rubber stopper (and the hook which enables the stopper to be suspended from the metre ruler in Question 2)
- ❑ vernier (or digital) callipers capable of reading to 0.1 mm; a hand lens may be provided to assist with reading the scale, if this is normally used; see note below

For use in preparation of apparatus

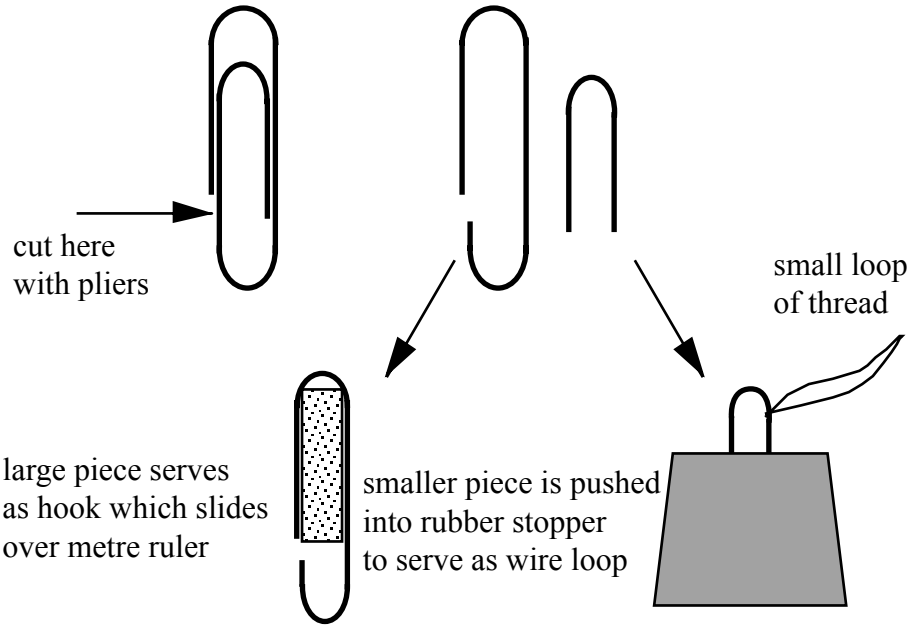
- ❑ pliers

Instructions and Information

Provision of vernier (or digital) callipers:
It is not necessary to provide callipers for each candidate. In order to facilitate the use of these instruments, it may be prudent to tell some candidates to start work on Question 2 before attempting Question 1.
Invigilators must supervise the transfer of the callipers between candidates.

The steel wire loop (and the hooks for Question 2) are produced by using pliers to cut a paperclip at the point shown in the diagram on page 7.
The smaller piece of wire can be pushed firmly into the smaller circular surface of the stopper to produce required steel wire loop. Attach a short loop of thread to the steel wire loop so that when the stopper is suspended from the horizontal ruler (as in **Figure 3** on the question paper), the stopper is suspended about 3 cm above the bench.

The discarded part of the paper clip will slide smoothly over the metre ruler to provide the hooks by which the stopper (and later the 300 g mass) can be suspended from the horizontal ruler, e.g.



For Question 1, place the stopper, with loop inserted, and the vernier (or digital callipers), on the bench.

The Examiners require the volume of the stopper to 3 s.f.

The diameters and the height of the stopper should be measured by the Supervisor before the examination.
The volume can be determined using the method shown in Question 1. If the diameters prove difficult to measure in a satisfactory manner, Supervisors may wish to determine these dimensions using a travelling microscope.
In a trial, the smaller diameter was found to 3.27 cm
the larger diameter was found to 3.83 cm
the height was found to 3.76 cm.

Using the equation given in Question 1, the volume was calculated to be $3.72 \times 10^{-5}\ m^3$.

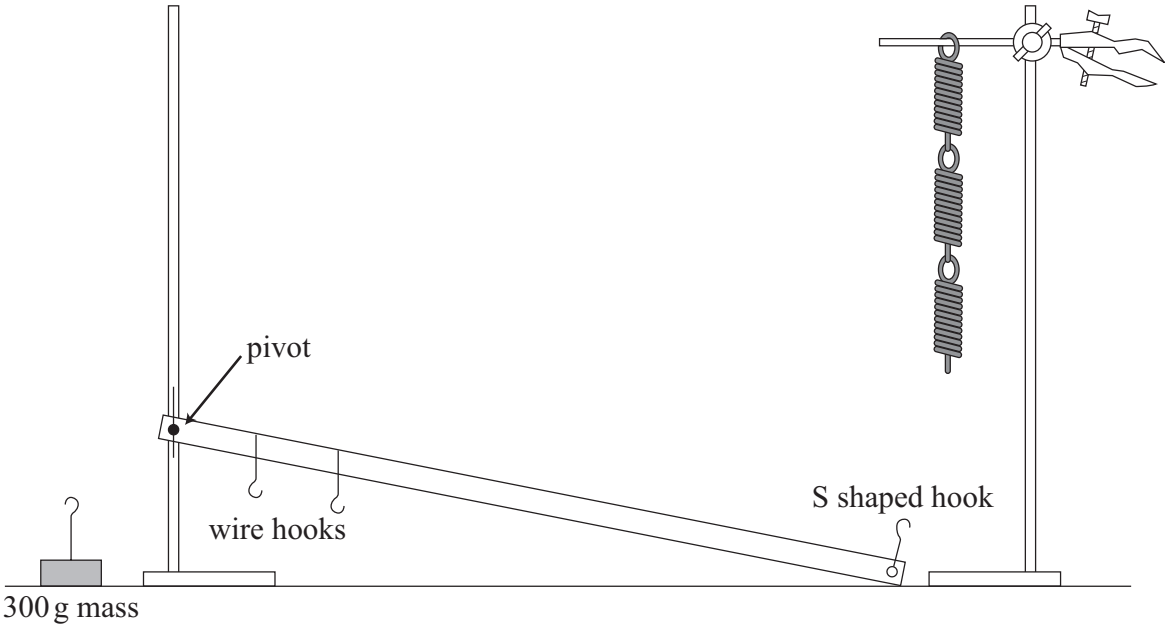
Question 2(a)

Apparatus

- ❑ the same rubber stopper with hook inserted, as used for Question 1
- ❑ slotted masses and hanger to total 300 g
- ❑ two hooks fashioned from large paperclips in the manner described above, to enable the stopper and the 300 g mass to be suspended from the metre ruler; these should be slid over the ruler before the arrangement shown in **Figure 2** is assembled
- ❑ metre ruler in good condition, small holes drilled in the median section at the 1 cm and 99 cm graduations; the diameters of these holes should allow the blade of a small screwdriver or similar to pivot the ruler at the 1 cm graduation and a hook, fashioned from a paperclip opened out into an 'S' shape, to pass through the hole at the 99 cm graduation (see **Figure 2**)
- ❑ 3 expendable steel springs, long extension, e.g. Philip Harris B8G87194, coupled in series; these should extend by about 300 mm when the 300 g mass is supported vertically from the lowest spring in the series
- ❑ retort stand, the rod of which need not be greater than 500 mm, fitted with a boss
- ❑ horizontal pivot; this can be the shaft of a small screwdriver or a smooth, stout nail and should be inserted through the ruler at the 1 cm graduation and secured in the aforementioned boss; the horizontal pivot should be arranged at the left-hand end of the ruler with the graduated face of the ruler facing the candidate; the height of the pivot above the bench should be about 200 mm
- ❑ retort stand, the rod of which should be about 750 mm, fitted with boss and clamp near the top; prior to the examination, the Supervisor should suspend the 300 g mass from the ruler about 800 mm from the pivot, adjust the height of the clamp supporting the springs until the ruler is parallel to the bench, as shown in **Figure 2**; tighten the boss to fix the height of the clamp
- ❑ setsquare; a conventional large plastic version will suffice.

Instructions and Information

Remove the 300 g mass from the ruler and place this, together with the setsquare on the bench alongside the apparatus, as shown in the following diagram.



The Examiners require the mass of the stopper to ± 0.1 g.

Question 2(b)

Apparatus
- ❑ apparatus is as for 2(a): ensure that the candidate uses the **same rubber stopper** with hook inserted, as used for Question 1 and Question 2(a)

Additionally
- ❑ one 100 g slotted mass, or 2 × 50 g masses, taped together, leaving a common slot for connection to the hanger
- ❑ 2 squat form 600 ml beakers, one of which is filled with water
- ❑ paper towels to mop up any spilled water

Place all on the bench beforehand; do not assemble the apparatus.

Examiners require no information for this question

Section A Task 2

Candidates are to investigate the equilibrium conditions for a number of coplanar forces.

Question 1

Apparatus

- ❑ rod or strong nail clamped horizontally to a rigid retort stand at a height of about 700 mm above the bench
- ❑ free-running pulley mounted with its axis horizontal, the pulley to be fixed to a retort stand with the top of the pulley about 500 mm above the bench; candidates should be able to move this stand and vary the height of the pulley to about 600 mm above the bench
- ❑ 1200 mm of thin string, one end of which is to be tied securely to the clamped rod; a small loop should be tied in the string at approximately 500 mm from the rod
- ❑ masses to total 200 g, the value of which is to be concealed by suitable wrapping; the mass should be labelled "X" and a light hook e.g. large paper clip bent into an 'S' shape, attached with which candidates may suspend this mass from the loop in the string
- ❑ 100 g mass hanger; additional slotted masses of values 1×50 g, 1×20 g, 2×10 g
- ❑ additional light hook, e.g. large paper clip bent into an 'S' shape, which candidates will tie to the free end of the string in order to suspend the slotted masses
- ❑ metre ruler and half metre ruler, each graduated in millimetres
- ❑ large set square, minimum edge 200 mm, to be manufactured from stiff card or artist's mounting board; a piece of material of A4 dimensions can be bisected diagonally to produce two set-squares
- ❑ simple plumb line

Instructions and Information

Candidates will complete the assembly of the apparatus to produce the arrangement shown in **Figure 5**. If the apparatus is to be subsequently used by another candidate it should be disassembled and fresh thread provided for the next candidate.

Examiners require no information for this question

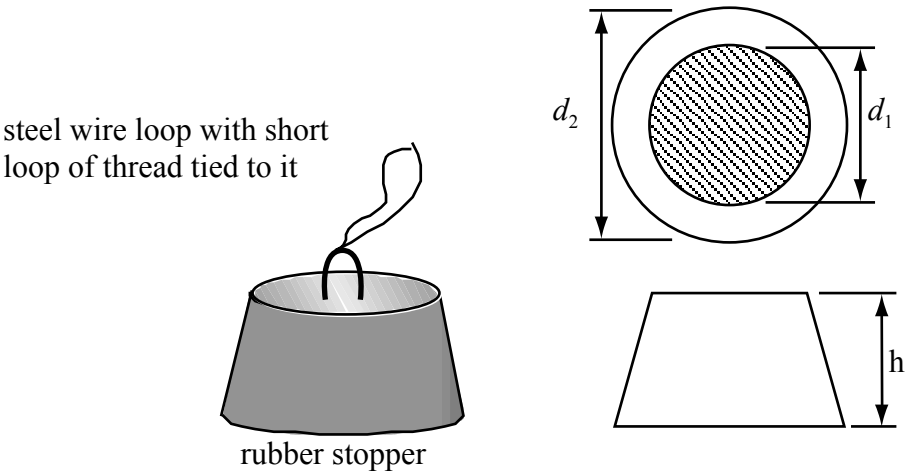
Note that when completing Section B of the test candidates should be provided with their completed copy of Section A Task 2, whereas candidates' copies of Section A Task 1 should **not** be made available to them.

Section A Task 1

You are to measure the volume of a rubber stopper by two different methods.
A steel wire loop has been fixed to the stopper. A short loop of thread has been tied to this steel loop.

1 This method of finding the volume of the stopper involves making measurements, using vernier callipers, of the dimensions shown in **Figure 1**.

Figure 1



1 (a) Make suitable measurements to determine

1 (a) (i) the smaller diameter, d_1, of the circular surface of the stopper

1 (a) (ii) the larger diameter, d_2, of the circular surface of the stopper

1 (a) (iii) the height, h, of the stopper. *(2 marks)*

1 (b) Ignoring the steel wire loop, evaluate the volume, V, of the stopper,

where $V = \dfrac{\pi h(d_2^3 - d_1^3)}{12(d_2 - d_1)}$

$V =$ *(2 marks)*

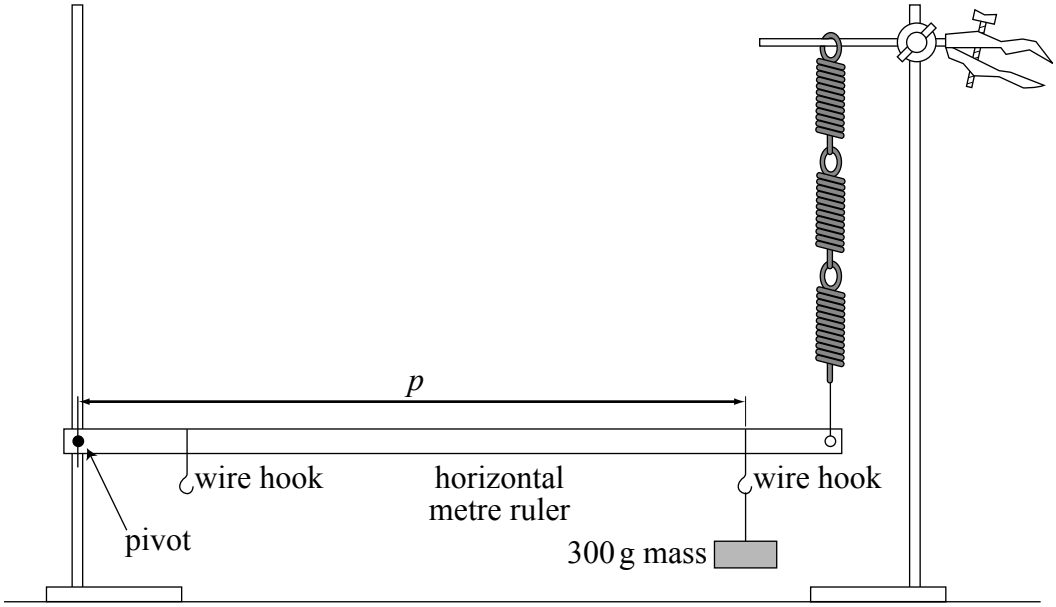
1 (c) Outline **one** difficulty you encountered when measuring the different dimensions of the stopper. *(1 mark)*

2 This method of finding the volume of the stopper involves making indirect measurements of the mass and density of the stopper.

2 (a) You are provided with a ruler pivoted close to one end. The free end of the ruler is supported by three coupled springs.
Do not adjust the height of the bosses attached to either of the clamp stands.

2 (a) (i) Two wire hooks are attached to the ruler; these can slide freely along the length of the ruler.
Using the wire hook that is further from the pivot, suspend the 300 g mass from the ruler and adjust the position of the mass until the ruler is horizontal, as shown in **Figure 2**.
Ensure the three coupled springs remain vertical.

Figure 2

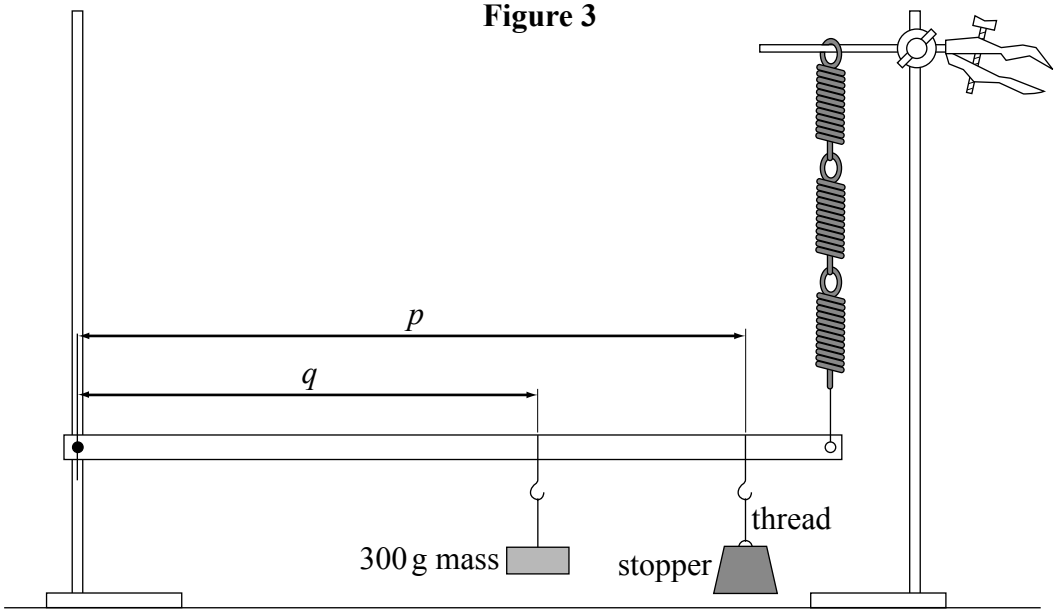


Measure and record the horizontal distance, p, between the pivot and the point of suspension of the 300 g mass.

$p =$

2 (a) (ii) Without changing the position of the hook, carefully remove the 300 g mass and use the thread to suspend the stopper from the hook.
Use the additional hook to suspend the 300 g mass from the ruler at a point between the stopper and the pivot.
Adjust the position of this hook until the ruler is once again horizontal, as shown in **Figure 3**.

Figure 3



Measure and record the horizontal distance, q, between the pivot and the point of suspension of the 300 g mass.

q =

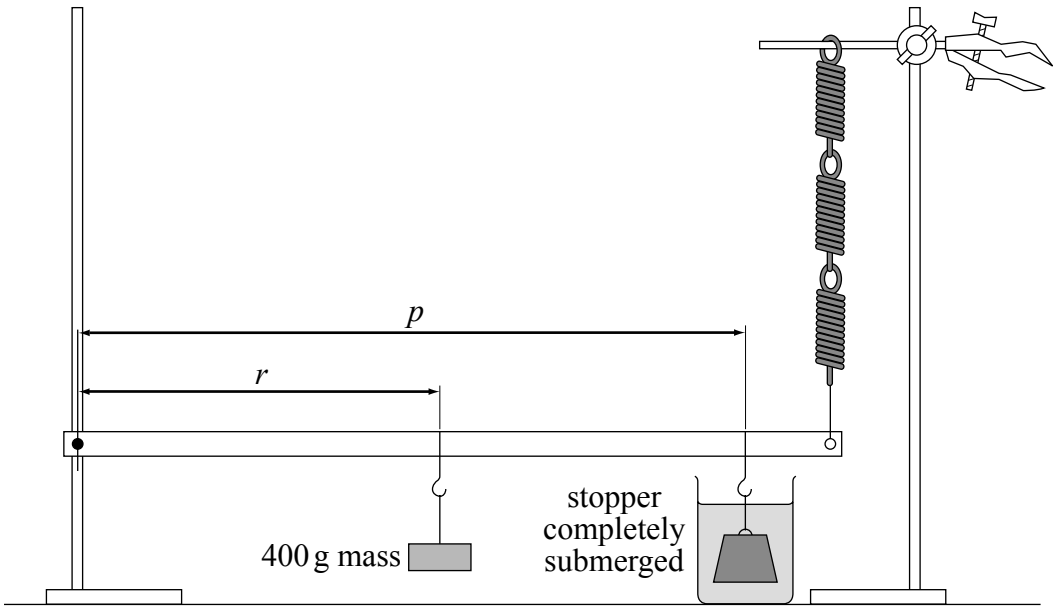
2 (a) (iii) Evaluate the mass, m, in g, of the stopper, where $m = \dfrac{300\,(p - q)}{p}$

m =

2 (a) (iv) Explain how you ensured that the metre ruler was horizontal before you measured p and q. *(3 marks)*

2 (b) **Without changing *p*,** carefully position the empty beaker directly below the stopper then pour water into the beaker until the stopper is completely submerged.
Using the additional 100 g slotted mass, increase the total mass suspended to 400 g.
Adjust the position of the hook from which the 400 g mass is suspended until the ruler is once again horizontal, as shown in **Figure 4**.

Figure 4



2 (b) (i) Measure and record *r*, the horizontal distance between the pivot and the point of suspension of the 400 g mass.

r =

2 (b) (ii) Determine ρ_s, the density of the rubber stopper, given by $\rho_s = \rho_w \times \dfrac{3(p-q)}{(4r-3q)}$

The density of water, ρ_w, = 1000 kg m^{-3}.

ρ_s =

2 (b) (iii) State and explain which of the linear measurements, *p*, *q* and *r*, has the greatest percentage uncertainty. *(3 marks)*

2 (c) Use your answers to parts 2(a)(iii) and 2(b)(ii) to determine the volume, *V*, of the stopper.

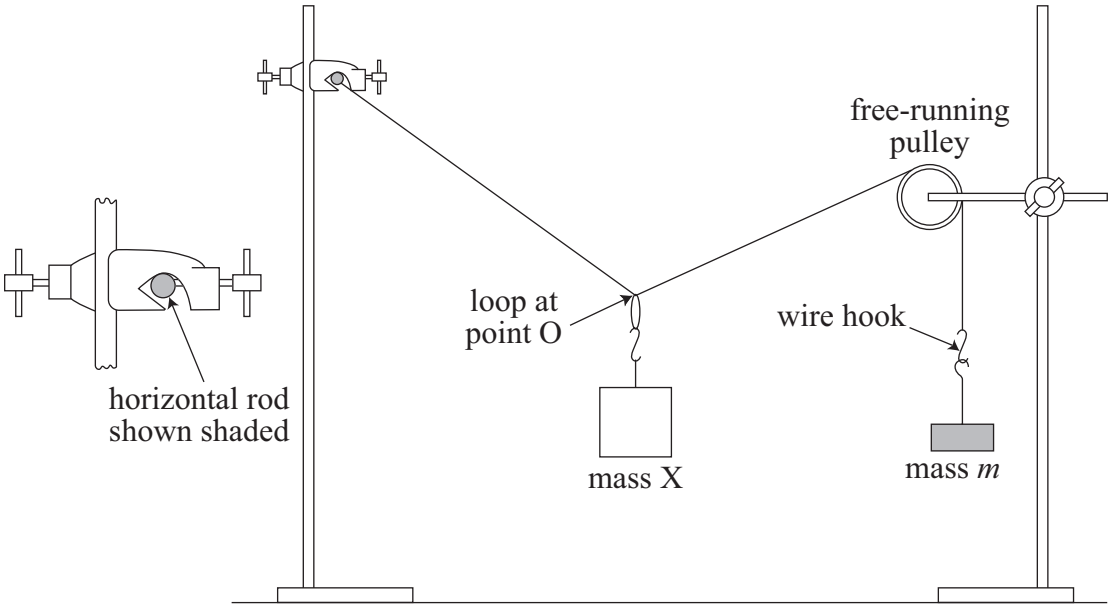
V = *(3 marks)*

Section A Task 2

In this experiment you will investigate the equilibrium conditions for a number of coplanar forces.

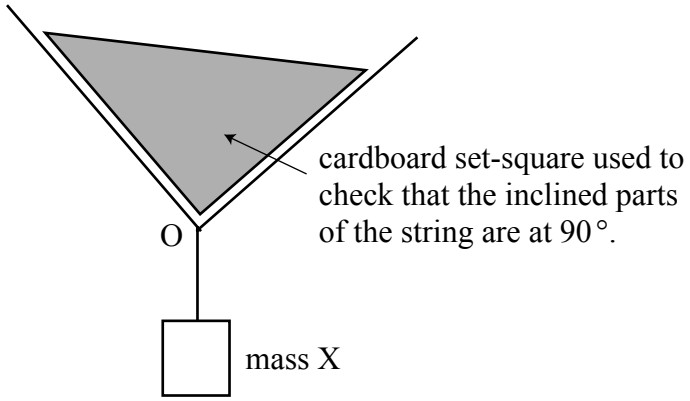
1 (a) Position the clampstands about 70 cm apart.
A length of string has been tied to the horizontal rod clamped in the retort stand.
A small loop has been tied near the middle of this string at a point, O.
Pass the free end of the string over the pulley clamped to the other stand.
Tie one of the wire hooks that are provided to the free end of the string and hang a mass, *m*, of total mass 100 g, from the hook.
Using the additional hook, suspend mass X from the loop at point, O, and allow the stem to regain equilibrium under the forces now acting.
The apparatus should now appear as in **Figure 5**.

Figure 5



Adjust the apparatus so that the system is in equilibrium and the inclined parts of the string are at 90° to each other.
You should do this by adjusting the height of the pulley and/or the distance between the stands. The alignment of the parts of the string can be checked using the large set-square, as shown in **Figure 6**.

Figure 6



1 (a) (i) Measure and record the horizontal distance, *d*, between O and the point at which the string is tied to the rod.

d =

1 (a) (ii) Measure and record the length, *L*, between O and the point at which the string is tied to the rod.

L =

1 (a) (iii) Estimate the uncertainty, in mm, ΔL, in your value of *L*.

ΔL = *(2 marks)*

1 (b) Investigate how *d* varies with *m* for **five** larger values of *m*, each time adjusting the system to keep the inclined parts of the string at 90° to each other.

Record below all your measurements and observations.
Note that the independent variable should be recorded in the **left-hand** column of your table. *(6 marks)*

1 (c) Plot, on the grid opposite, a graph of your readings for part (a) and part (b) with *d* on the vertical axis and *m* on the horizontal axis. *(8 marks)*

Section B

1 (a) Determine the gradient, G, of your graph.

$G =$ *(2 marks)*

1 (b) Evaluate $\frac{L}{G}$

$\frac{L}{G} =$

(2 marks)

2 (a) Use your answer to (a)(iii) in Section A Task 2 to calculate the percentage uncertainty in L. *(1 mark)*

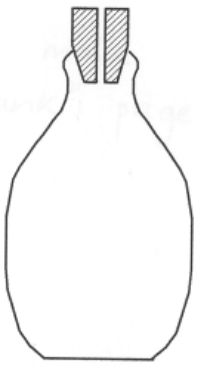
2 (b) Assuming the percentage uncertainty in G is double the percentage uncertainty in L, calculate the percentage uncertainty in your result for $\frac{L}{G}$. *(1 mark)*

3 Describe the procedure you used to measure d.
You may wish to use a sketch to illustrate your answer. *2 marks)*

4 In Section A Task 1 you calculated the density of the rubber stopper. The accuracy of your result depends on whether the water in which the stopper was submerged contained dissolved impurities.

The density of a sample of water of unknown purity can be compared with the density of pure water using an instrument known as a *pyknometer* or density bottle. The density bottle has a glass stopper, which has a fine hole through it so when the bottle is filled the excess liquid rises through the hole and drains away. This ensures the bottle will always contain the same volume of whatever liquid is put in it.
This type of density bottle is illustrated in **Figure 7**.

Figure 7



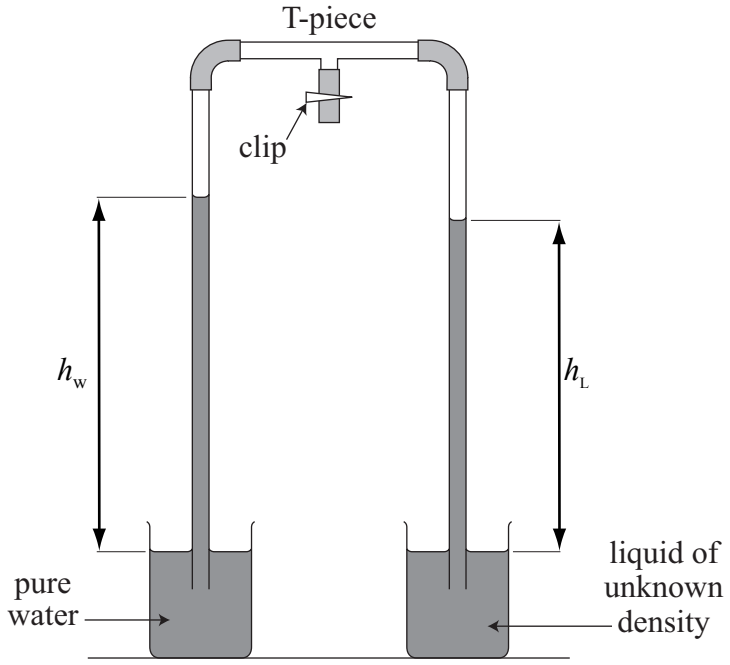
A student makes the following measurements in order to determine the density of a liquid.

Mass of empty density bottle = 18.07 g
Mass of density bottle when filled with pure water = 44.12 g
Mass of density bottle when filled with liquid of unknown density = 45.20 g

Use the student's data to show the density of the liquid $\approx 1040\,\text{kg}\,\text{m}^{-3}$.
The density of pure water = 1000 $\text{kg}\,\text{m}^{-3}$. *(5 marks)*

5 Another student researches methods of comparing the densities of two liquids and discovers a method known as *Hare's* apparatus.
The apparatus, shown in **Figure 8**, includes two vertical glass tubes connected at the top by a glass T-piece.

Figure 8



These tubes dip into separate beakers containing the liquid of unknown density and pure water. Air is sucked through the centre limb of the T-piece and the clip closed. Removal of the air causes the liquids to rise up their respective tubes but the difference in the densities means that the liquids are raised through different heights, shown by h_L and h_w in **Figure 8**.
By briefly opening and then closing the clip the student acquires the data shown below.

h_L/cm	h_w/cm
71.0	74.2
65.9	68.9
51.2	53.5
40.9	42.8
37.7	36.0
24.1	25.2

The formula for Hare's apparatus is

$$density\ of\ water \times h_w = density\ of\ the\ liquid \times h_L.$$

5 (a) The student suspects that one row of data may contain an unreliable measurement. State and explain which row contains the unreliable data. *(2 marks)*

5 (b) (i) Showing your method clearly and rejecting the unreliable data, use the remaining data produced by the student to determine the density of the liquid. *(5 marks)*

5 (b) (ii) State and explain how the student could use the data to determine the density of the liquid by a graphical method. *(2 marks)*

5 (b) (iii) Explain how the presence of unreliable data would be identified on the graph. *(1 mark)*

5 (c) Identify one possible source of random error in the measurements in the student's experiment and explain how this error can be overcome.
You may wish to use a sketch to illustrate your answer. *(2 marks)*

END OF QUESTIONS

There are no instructions printed on this page

General Certificate of Education
June 2009
Advanced Subsidiary Examination

PHYSICS (SPECIFICATIONS A AND B) PHA3/B3/XTN
Unit 3

SUPERVISOR'S REPORT

When completed by the Supervisor, this Report must be attached firmly to the attendance list, before despatch to the Examiner.

Information to be provided by the centre

Section A Task 1
Question 1 The volume of the stopper to 3 s.f.

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Question 2(a) The mass of the stopper to ± 0.1g

.....

Question 2(b) No information is required

Section A Task 2
Question 1 No information is required

Supervisor's Signature.....

Centre Number.....

Date.....

Centres may make copies of this Supervisor's Report for attachment to individual scripts where necessary.

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