ASSESSMENT and QUALIFICATIONS ALLIANCE

## General Certificate of Education

# Physics 6451

*Specification A*

## PHAP Practical Examination

# Report on the Examination

*2007 examination - June series*

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Set and published by the Assessment and Qualifications Alliance.

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## General Comments

This was a paper in which candidates could score high marks in AO3b (implementing) and in AO3c (applying evidence and drawing conclusions). At the E/U boundary, candidates could typically gain ten to twelve marks in these AO but often made little progress with the other aspects of the paper. In contrast, candidates at the A/B boundary were able to score significantly better marks in AO3a (planning) and AO3d (evaluating evidence and procedures).

The paper seems to have discriminated slightly less well overall this year than in either 2006 or 2005 and the mean mark is slightly higher than in 2006.

Question 1 posed a situation that candidates had not met before; the problem was one in which there were two independent variables (frequency of the sound produced by the loudspeaker and port dimension) and a dependent variable (sound amplitude). Many chose to make frequency a control variable or identified it at a dependent variable. The correct method required candidates to set out a method in which, for a given port, the amplitude was recorded for a range of input frequencies and then the procedure was repeated for each of a range of port dimensions. A point that seems lost on some candidates is that, if they propose that some sort of graph is drawn, then they must previously have explained how the range of data this requires was to be produced.

Even where the candidates got confused over the nature of the dependent and independent variables, most were able to identify some relevant control variables. The most prudent answers picked up marks for identifying procedures to overcome difficulties and it was in respect of these answers that the attention to detail of the teacher preparing the candidates was most apparent.

The attempts by some candidates to provide generic answers proved of limited use. The trick with such answers is spotting where and when to apply them. An idea, seen in many scripts that attracted no credit, was that the frequency of readings should be increased around the turning points of the frequency response curve, but as Figure 2 shows, this is a graph without such a point. Nor does ‘reducing the uncertainty in the length of the port by using longer ports’ make much sense in the context of the problem. The use of ‘loud’ sound to ‘reduce the uncertainty in the amplitude’ showed a little more insight, but overlooked the use of the Y-gain on the cro to overcome the problem. As usual, the ‘repeat and average measurements’ idea, unless given in an appropriate context, could gain no marks.

Candidates will know that separate marks for quality of written communication are not given in this paper; but they should understand that the quality of their language and technical vocabulary may have a significant bearing on the marks they gain. Many disadvantaged themselves by using phrases such as ‘the volume of the loudspeaker’ when they meant the amplitude of the sound produced. The use of a signal generator did not feature in many scripts. In part (e) (ii) of Question 2, many said they would use a ‘laser’ to monitor the motion of the tethered mass. Thankfully, key words such as ‘uniform’ and ‘control’, and the idea of ‘fiducial mark’ now appear to be understood better.

Despite the inevitable number of unsuccessful attempts, there were some excellent and even outstanding answers, where the ideas given far exceeded the expectations of the examiners. Foremost among these was the idea (seen in more than one script) that the frequency response of the microphone should be flat over the range of frequencies used for the port comparison.

Despite the generally higher marks than in the previous two years in Question 2, extensive use was made of the mark range. There was less reliance in the work on mathematical competence than in 2006 but a much higher premium on careful working and small errors in the determination of the gradient, *G*, proved costly when this result was incorporated into $\frac{G}{\mu}$.

Candidates should understand that their working on gradient calculations is checked, as is the accuracy with which they plot their points on the grid. While the scaling of most of the graphs seen was adequate, the truncation of the intermediate data for the period (often, illogically, reduced to two significant figures) may have led to problems for some.

There were marks accessible to candidates of all ability in both questions, but there were parts in which the candidates had to think carefully about the methods they employed, e.g. part (a), and the procedures they described, e.g. (e) (ii). While it is clear from a majority of scripts that centres are using the guidance given through mark schemes and reports on the examination to develop the candidates' ability to respond to planning questions, a depressing number still find it difficult to make much progress in AO3d. A number still think that in s.h.m. experiments, it is important that the same initial amplitude is used in order to make a fair test. Many think that a data logger is an input/process device rolled into one or if they appreciated the need to use a light gate, then they think it can be used to produce a displacement time graph. Candidates must be encouraged to strive for more success in the AO3d questions. Time spent discussing practical methods and explaining techniques provides a valuable resource for the candidates in tackling this style of question; this can also form a valuable part of teacher demonstrations e.g. of data logging, or in other situations where candidates do not get first hand experience in using equipment.

**Question 1**

Candidates were required to devise a procedure that would identify how one key dimension of the port in a bass reflex loudspeaker influenced the speaker's frequency response.
A mark for measuring one key variable (either the length or the diameter) of the port using a ruler or vernier callipers was gained by most. The use of a micrometer screw gauge was rejected, as was the suggestion that 'width', 'thickness' or 'volume' would be measured.
The means to measure the amplitude of the sound produced by the loudspeaker was more difficult, not least because some did not identify 'amplitude' properly. The examiners required that the input and process devices be compatible; analogue devices such as a microphone must be connected to a cro while a digital device like a sound sensor must be connected to a data logger. Vague suggestions about 'sound receiver/detector/receptor' were given no credit. Relatively few opted for the simpler idea of using a decibel meter and of those that did, it was obvious that very few had direct experience of using such a device.

Confusion over strategy spilled over into the measuring marks for those who wanted to use the microphone/cro to measure the frequency of the sound. Relatively few identified that a signal generator (or words to that effect) was required to enable a range of input frequencies to be supplied to the loudspeaker. Sometimes this appeared in a diagram although the quality of many left a lot to be desired. The representations of the proposed arrangement were always graphical and correct circuit symbols for microphone and cro were never seen.

A significant number of those who elected to use a signal generator did so in order to keep the frequency constant and so forfeited all three marks for strategy. Others thought that a music sample would supply the range of frequencies required, overlooking the need to test the response of the speaker one frequency at a time.

Confusion over the nature of frequency as a variable was apparent in those that thought the frequency would vary according to the power supplied to the loudspeaker; some showed sketches of speakers with frequency and volume controls marked on the cabinet.

There was no insistence that frequency be measured; examiners accepted that the signal generator was properly calibrated and for those that followed this route the remaining strategy marks were easy to obtain.

Providing that a clear intention had been indicated that the input frequency would change and corresponding amplitude readings taken, the suggestion that a frequency response curve would be drawn was accepted. Many showed a number of such curves (one for each port configuration) on the same axes and this satisfied the requirement that some form of comparison between the different ports be carried out. Some imaginative ideas suggesting how a more detailed comparison is made were given; these included ideas about finding the area under each curve using integration.

To access control marks several started by discussing the need to test the behaviour of the speaker with no port fitted, although this idea did not attract credit. Many possible measures were proposed, the more popular being the loudspeaker to microphone distance, the other (non-variable) port dimension and the amplitude/voltage/power supplied to the loudspeaker. Candidates who suggested that the amplitude of the sound from the loudspeaker should be constant had clearly lost the thread of their argument.

The more successful responses to do with procedures in overcoming difficulties concerned uncertainty in measuring the port dimension (repeat and average was required). Some also thought about the amplitude measurements and wrote about adjusting the Y-gain to keep the trace filling the screen (other valid ideas given included turning off the time base or measuring vertically from peak to peak).

The most popular, and generally unsuccessful, procedure suggested was to soundproof the room. Examiners required some detailed discussion of how this would be done; ‘keeping quiet’ or ‘shutting windows’ was not good enough.

For the small number using decibel meters, a valid suggestion given credit was to record the background sound level before performing the experiment and use the corrected measurement in the subsequent analysis.

In AO3a (planning) candidates at the A/B boundary typically scored five out of eight while those at the E/U boundary usually got one or two.

**Question 2**

Candidates were required to measure the period of vertical oscillations of a variable mass suspended between three expendable steel springs (two above and one below).
Some centres reported difficulties with new springs which tended to deform under higher loads. On contacting AQA, they were told to reduce the range but not the number of masses available to their candidates. The scripts seen showed that in such cases the candidates were not disadvantaged.

In part (a), candidates were required to determine $\mu$, the vertical deflection per unit mass added to the spring network. For credit, the measurements made were required to be recorded to the nearest millimetre and to be for a total extension of at least 50 mm. The result for $\mu$ was required to be given to at least two, but not more than four, significant figures. Some candidates gave the result as the extension per 100 g of mass, which forfeited the mark for $\mu$, but this error was taken into account in the marking of $\frac{G}{\mu}$.

The tabulation of raw data in (b) was nearly always universally successful; most candidates recording at least six sets, with $T$ obtained from at least 20 cycles. Those who did not then repeat the timing of $20T$, put themselves at a disadvantage when it came to answering (e) (i), since they could not then use the 'repeat and average' argument. Marks were withheld for false data, i.e. if the candidate had recorded $T$ as $nT$, but very few measured $T$ by counting oscillations in a fixed time. Some candidates recorded the total mass (including the hanger) suspended between the springs rather than the additional mass added; in such cases the graph drawn passes through the origin of the graph.

The significant figure mark in (b) was for the raw readings of $nT$; these were required to be consistently to either 0.1 s or to 0.01 s. Although not penalised, it was odd to see that the derived data (for $T$) recorded alongside was frequently truncated to two significant figures and this may have affected the quality of the $T^2$ data transferred to the graph later.

Perhaps influenced by the way they had recorded the period, many truncated the $T^2$ data, recorded in (c) to two significant figures, forfeiting a mark. This did not seem to affect the scatter on the graph unduly and where seven sets were recorded it was frequently the case that at least six points were either on or very close to the best-fit line and thus earned the Q mark.

Candidates at about the A/B boundary typically scored seven or eight out of eight in AO3b while those at the E/U boundary could often obtain at least six marks.

A frequent error among less able candidates was to not supply the correct unit with the $T^2$ label on the vertical axis, but nearly all the graphs seen were appropriately scaled. Where marks were withheld for graph scales, this was to do with the use of difficult intervals between sub divisions along an axis. Some candidates are leaving too large a gap between such markings, making it difficult to interpret the work.

In most cases the quality of the measuring was sufficiently good to produce a very good best-fit line. Gradient measurement was undermined by carelessness in reading off the co-ordinates at each apex of the triangle. Examiners would like to see the calculation of the gradient set out in full.

The evaluation of $\frac{G}{\mu}$ proved a good discriminator. The incorporation of the result from (a) required that the units given previously (some gave $mkg^{-1}$ or variations thereof, while others gave m, cm etc) had to be taken into account when deciding on the unit to give with $\frac{G}{\mu}$. A surprising number used $T^2kg^{-1}$ although, for the more able candidates, this part of the problem was straightforward. The numerical part of the answer required a value between 3.79 and 4.27 although those that truncated their result to two significant figures gave themselves less scope for error.

Candidates at about the A/B boundary typically scored six or seven out of eight in AO3c while those at the E/U boundary could often obtain about five marks.

In (e) (i), candidates could give a range of valid procedures, any three of which could earn both marks. For those claiming to have timed multiple oscillations or to have repeated and averaged their *nT* results, evidence of this was required in part (b) of the script.

In (e) (ii), candidates were required to identify that a non-invasive input device (a light gate or a motion sensor) be connected to the data logger and to say where such a device should be positioned. If no suitable input device was suggested (and this was the case in many scripts seen) then no credit was given in (e) (ii). Many struggled to give a clear explanation of how the output from a light gate could be used to measure *T*. The best answers seen showed a timing diagram giving the output from the gate as a digital signal and the interval between one rising edge and the next but one rising edge identified as the period. Lots of answers were seen in which statements along the lines of '20 readings were recorded and this was equal to 10*T*' were given. These answers gained no credit, since an initial 'reading' or obscuration is required to begin the timing interval. It is clear that many candidates had not given this question sufficient thought and some were under the impression that the light gate could be positioned at the points of maximum amplitude.

In (e) (iii), many correctly identified that resonance was the phenomena responsible for the phenomena described (although many wrote about 'simple harmonic motion', 'circular motion' or 'gravity'). In explaining how the lower spring prevented this from happening, some claimed that its presence changed the natural frequency from that of a two spring system (true) but that would not prevent resonance at other forcing frequencies. Others said that the lower spring had a different natural frequency from the two at the top, without appreciating that it was the system as a whole that they should be considering. Another popular idea was that the lower spring provided damping, but this did not attract credit. A simple statement along the lines that the lower spring opposed the horizontal motion involved in (simple) pendulum oscillation was all that the examiners required.

Candidates at about the A/B boundary typically scored two or three out of six in AO3d while those at the E/U boundary would typically obtain one mark.

**Mark Ranges and Award of Grades**

Grade boundaries and cumulative percentage grades are available on the Results statistics page of the AQA Website.