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**General Certificate of Education (A-level)**
**June 2011**

# Physics B: Physics in Context PHYB4

## (Specification 2455)

## Unit 4: Physics inside and out

# *Report on the Examination*

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**GCE Physics, Specification B: Physics in Context, PHYB4, Physics Inside and Out**

**General Comments**

Candidates were able to make good progress with each question and with the paper overall. However, many candidates do not find it easy to maintain an even standard across a paper such as this which tackles many different ideas in a range of practical situations. Particular errors, where they existed, were inability to provide clear unambiguous explanations with sufficient relevant detail and inability to identify the most appropriate physics that they have learnt to solve novel problems, in particular where two or more steps were involved. For example, there was a tendency to rely on the use of equations of uniformly accelerated motion in motion without thinking whether it was more appropriate to use conservation of energy and or momentum. Presentation overall was good but some candidates presented work in handwriting that was often unreadable.

**Question 1**

In part (a), most candidates were able to make some reference to weight being mass multiplied by gravitational field strength although this was often expressed simply as $W = mg$ or, too loosely, as mass × gravity. Many did not go on to explain why gravitational field strength was not constant. Relatively few stated that mass was dependent only on the matter that was contained in the object. A few pointed out that, in fact, there could be relativistic increase in mass and these were rewarded.

A majority of the candidates identified zero potential at infinity in part (b)(i), but explanations of why this led to negative values closer to the Earth were often unconvincing. Candidates needed to say more than 'the field is attractive'.

Many candidates had difficulties with the straightforward exercise in part (b)(ii). Rather than simply analysing the data to show that $Vr$ at each position produces a constant, many used the equation $V=GM/r$. Although candidates were not penalised for a correct approach using this method as long as they were thorough, the additional arithmetic often led to errors. In this type of question it is important that candidates give an appropriate reason why the analysis demonstrates consistency of the data with the law that is proposed. This was often not the case and responses were frequently a jumble of calculations from which the examiner was, presumably, required to draw their own conclusion.

Many candidates overcomplicated part (b)(iii) owing to inadequate understanding of the information that was provided in the table. Some candidates made no use of the table data at all and used $GMm(1/r_1 - 1/r_2)$. Although this was against the spirit of the question, candidates were allowed one of the available marks provided that this was completed successfully but many ran into problems with the arithmetic. Some used change in PE = $mgh$.

Part (c)(i) was done very poorly. Although knowing that they had to use $\frac{1}{2} mv^2$, many did not know that the speed of the satellite in an orbit can be found using $GMm/r^2 = mv^2/r$.

Because of their inability to produce an answer to part (c)(i) there were a high proportion of the candidates who omitted parts (c)(ii) and (c)(iii). Most of those who found an answer to (c)(i), even if incorrect, were able to score here by realising that the answer was the difference between 12 GJ and their answer to (c)(i).

There were few correct answers to part (c)(iii) because most candidates paid no attention to the signs of the changes, the KE change being a decrease and the 10 GJ PE change an increase.

**Question 2**

The most common error in part (a) was to omit *g.* A suitable unit was usually given. The unit 'W' would have been the preferred response but $J\ s^{-1}$ and $N\ m\ s^{-1}$ were also accepted.

Many candidates showed poor understanding of physics in part (b). The solution required them to subtract $\Delta E_k$ from $\Delta E_p$ to find the work done against resistive forces and equate the difference to *Fs.* The use of equations of uniformly accelerated motion was common although this clearly is not a case of uniform acceleration. Another common incorrect approach was to calculate the time to descend as being the 63/22, which is incorrect because of the acceleration, and then to use change in momentum = *Ft* to find *F.* Candidates who made a reasonable attempt and gave the answer to two significant figures gained the final mark but many felt that three significant figures was acceptable even though the data was provided to two.

In part (c), many referred to air resistance and went on to gain a further mark for why it should change. Some of those who mentioned friction referred to friction 'between the wheels and the track' although it is not a sliding situation, but there were many who appreciated the effect of the changing angle of the track on likely frictional forces within the system.

For part (d), most candidates who used $F = mv2/r$ ignored the effect of the gravitational force arrived at 12 m. The correct answer of 16.4 m was obtained by relatively few candidates.

**Question3**

It was disappointing that more candidates could not successfully solve the simple problem in part (a)(i). In the rest situation $mg = k\,\Delta L$ and so the overall length = 20 + $\Delta L$. Some dubious physics was seen in responses where candidates used $T = 2\pi\sqrt{(m/k)}$ to find $T$ and then $T = 2\pi\sqrt{(L/g)}$ to find $L$. It was rarely clear in responses whether candidates knew that in this instance '*L*' in the formula was the equilibrium extension. Many candidates did not add on the 20 m to give their final answer.

Analysing the problem in part (a)(ii) proved too difficult for the majority of the candidates. To find the height of **P**, most candidates added either 2.6 m or the extension or both of these to 20 m.

For part (b)(i), candidates needed to state the equation or equations they were using, show clear substitution of data and then answer to more significant figures that the value given in the question, so demonstrate that they have done the arithmetic. One or more of these steps were often omitted.

Part (b)(ii) was generally done well.

For part (b)(iii), there were a number of aspects that needed to be thought about to draw a correct sketch. Only careful candidates were able to score three marks for the question even though the marking allowed for one aspect to be overlooked. Many graphs were drawn far too carelessly, even for a sketch graph. Although no values were required on the *v* axis it was essential that the 0 was evident either explicitly or by implication. If this was not the case then the positive and negative velocities during the oscillation could not be shown. Graphs needed to show two complete (reasonably sinusoidal) oscillations with an unchanging period; the correct period of about 5 s on the time axis; a velocity that started at 0 and increased in a positive direction initially and a decaying amplitude.

Part (c)(i) was a demanding question and although most candidates appreciated, perhaps intuitively, that **P** would need to be raised, few were able to make a sensible comment as to why this should be the case and even fewer to give a convincing response worth full marks. Concentrating on tension ('more tension to overcome the weight') rarely led anywhere. Candidates needed to consider the rider's position above the ground when the rider comes to rest or, for example, to use energy considerations to discuss the maximum height that the rider would reach without any change in the height of **P** etc.

There were some very good responses to part (c)(ii) that used conservation of energy and the best went on to explain that the rider could not go below the start point unless there was some extra energy input at some stage during the first oscillation. Many gained some credit for responses that concentrated on the loss of energy that occurs when there was air resistance – rather than what would happen without.

The part of the question that asked *what would happen to the rider?* was usually ignored. This was a descriptive part which required candidates to appreciate that the rope would reach an unstretched length while the rider would still have KE and do go into free flight before returning.

**Question 4**

There were some very good responses to part (a). However, most answers were incomplete. Many gained credit for explaining the events in the combustion chamber and the ejection of fast moving gases through the nozzle. Commonly, candidates went on to state that the momentum of the rocket and fuel was zero at the start which is not the case in this question as they are both moving at 15 km $s^{-1}$. Candidates usually went on to say that momentum is conserved without any detail and/or that the momentum of the fuel = the momentum of the spacecraft. The point that was overlooked was the fact that as the fuel is ejected the change in momentum of the spacecraft in a given time period must equal the change in momentum of the fuel in the same time period. Answers in terms of action and reaction were usually unconvincing and there were a number of candidates who thought that the fuel pushed on the Earth to accelerate the spacecraft.

Most candidates knew which formula to use in part (b)(i) but misunderstanding of the meaning of the terms in the equation led to wrong answers. Many used 15 (km $s^{-1}$) for *ve* and some added the 2500. The 'In' part of the formula, was often 30000/5000 or 35000/30000. A mark was available for adding the 15 km to the change in speed to give the final speed but relatively few gained what should have been an easy mark.

Many candidates seemed uncomfortable applying momentum in problem solving for part (b)(ii) and this fairly straightforward problem proved to be too difficult for many candidates. One route was the use of change in momentum of fuel per second to give the accelerating force followed by use of $F = ma$. Alternatively, applying change in momentum of the fuel in one second = change in momentum of remaining mass of the spacecraft gave the change in velocity per second directly. A common incorrect approach was to determine the total time for all the fuel to be used (30000/55 = 545 s) and then use what the candidate though was the change in velocity (usually 15000, 20000 or 4900 divided by this time to find the acceleration.

Poor graph drawing was again evident in part (b)(iii). It was surprising how many candidates did not identify the starting velocity of 15 km $s^{-1}$. The increasing acceleration was often recognised, as was the final steady speed but the instant at which the speed became constant was frequently unclear.

Many gained the mark in part (b)(iv) for an acceptable explanation of either the increasing acceleration or the constant velocity. However, most described the graph rather than offering an explanation.

**Question 5**

Part (a)(i) was done well. The most common error was misreading the wavelength at which the peak occurred.

For part (a)(ii), many did not to realise that the maximum energy of the X-ray beam was the same as the energy of the electrons that leave the electron gun. The fact that 20% of candidates made no attempt at this and part (a)(iii) was disappointing as these are fairly routine problems on this part of the specification.

Answers to part (a)(iii) ranged from values of the order of $10^{-40}$ W to $10^{20}$ W, with no suggestion from candidates that something had gone wrong.

Most gained a mark in part (b) for stating that it was to prevent overheating or melting of the target. Good answers provided further detail and explained clearly that most of the energy transferred from the electron beam became internal energy in the target.

There were some excellent accounts in part (c) that explained in detail the production of both continuous and line spectra. Those in the middle band usually gave a good account of the production of either the continuous spectrum or the line spectrum or superficial accounts of both. The poorest parts of the discussions in both the higher and middle mark bands were an adequate explanation of how the deceleration of electrons gave rise to the continuous spectrum and failure to explain that the photon energy of the radiation was related to the difference between the electron energy levels when relaxation occurs. The poorest answers usually said little more than X-rays are produced when electrons strike the target and often contained much irrelevant material about what happens to the X-rays as when they are used in diagnosis. Few of these introduced the concept of a photon being produced in a single interaction of an electron with the target. A significant proportion of the less able candidates thought that photons were striking the target to produce X-rays or that photons (or sometimes protons) produced inside the target were converted into X-rays.

**Question 6**

Part (a)(i) related to one of the standard demonstrations of electromagnetic induction which students are likely to have seen so it was anticipated that the observations should have been direct recall for most candidates. For those who had not seen the demonstration, it should have been fairly easy to predict and explain the outcome provided that the candidate understood the laws of electromagnetic induction. However in this part, and the parts that followed, many candidates showed that they had an inadequate understanding of these ideas and of the terminology needed to cope adequately electromagnetic phenomena. Terms, such as ‘induced’ and ‘eddy currents’, were inappropriately used. The concept that induced emfs are produced by rate of change of flux or that flux cutting means that a conductor actually moves through lines of flux (or vice versa) were far from established in the minds of many candidates. Many clearly thought (or at least their answers implied) that no changes in flux or movement were necessary to induce emfs and all that was needed was for a flux to link the coil or that a flux needs to exist where the conductor is placed. When discussing the direction, many stated only that the current was opposite to that in the first coil because of Lenz’s law, whereas the direction of the current in coil 2 relative to that in the coil 1 depends on whether the flux produced by the current in the coil 1 increasing or decreasing.

In part (a)(i) answers often related to only one of the ammeters which was often not identified as A1 or A2. In particular, the fact that that ammeter A2 showed only a kick or momentary reading was rarely mentioned. Some candidates simply quoted the laws without applying them to the demonstration.

The important point in part (a)(ii) was that A2 gives a (momentary) reading opposite to that in part (i), with a subsequent explanation in terms of Lenz’s law. Simply stating that it was due to Lenz’s law was not enough.

Part (a)(iii) was more straightforward than the previous two parts. Many appreciated that the current increases in both coils and that the increased current produces a higher magnetic flux density or linkage. However, many did not explain that this leads to an increase rate of change of flux to produce the higher reading in A2.

Disappointingly, few candidates attempted to determine the gradient of the graph at 0.5 s in part (b)(i). Most used the instantaneous values of 7.2 mT and 0.5 s. Others subtracted the value at time = 0 (ie 1.6 mT) from the 7.2 mT. A mark was available for correctly calculating the area of the coil and another for an attempt using $(AN\Delta B)/\Delta t$. However, few could take advantage of these compensatory marks, as $A$ or $N$ were often not included.

Many candidates successfully completed part (b)(ii).

Although there were some very good answers in part (c), most answers were poor and lacked detail. The intention was that candidates suggest modifications to the timing experiment, but many candidates clearly misunderstood the question, choosing to abandon the experiment for other methods such as resistivity surveying. To allow for this, marks were awarded for stating another method with some detail and further credit for giving good detail.

Many gained credit in part (d) for recalling that ultrasound is a longitudinal/mechanical wave and that microwaves are electromagnetic/transverse waves. Others gained credit for appreciating that to determine depth, the total time between transmission and reflection had to be determined and then halved and multiplied by the wave speed. However, relatively few were able to provide a complete response to both aspects.

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