Version 1.0: 0310

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 2456

Specification B: Physics in Context

PHYB4 Physics Inside and Out

Report on the Examination

2010 examination - January series

Set and published by the Assessment and Qualifications Alliance.

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales (company number 3644723) and a registered charity (registered charity number 1073334). Registered address: AQA, Devas Street, Manchester M15 6EX
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GCE Physics, Specification B: Physics in Context, PHYB4, Physics Inside and Out

General Comments

All but the least able candidates attempted the majority of parts of most questions and there appeared to be little problem relating to time constraints. It appeared that some candidates were unfamiliar with the concepts of electromagnetic induction, resonance and the production of characteristic X-ray spectra.

The more able candidates showed a good knowledge and understanding of the material. Most candidates' work would benefit from greater structure and in particular 'show that' questions must include equations, substitutions and answers to an appropriate number of significant figures. There were no parts of this paper in which the units were penalised but a high proportion of candidates did not gain the mark awarded for using two or three significant figures in question 5 (b)(ii).

Question 2 (c)(ii) required candidates to communicate their physics coherently with due care to spelling, punctuation and grammar. Technical words were too frequently misspelt and many candidates' answers lacked fluency and organisation. Candidates would be well advised to consider the briefest of essay plans before starting to commit pen to paper.

Question 1

Many candidates gained both marks in part (a)(i) – although few clearly labelled the forces as being the normal reaction and the weight (sensible symbols being condoned in this case). Candidates labelling the weight as 'gravity' were penalised as was diagrams for which the arrows did not appear to come from the rider's centre of mass or the floor.

Part (a)(ii) provided a very straightforward mark, lost by only a very small number of candidates. There was no penalty for poor use of significant figures here but many candidates quoted the weight to an unreasonable number of digits.

Many candidates did well in part (a)(iii). There was quite frequent confusion between the reaction and the resultant forces and a number of candidates were relatively liberal with their inclusion of minus signs to ensure that the reaction was reduced. Most understood that it is the normal reaction which gives us the sensation of weight.

In part (b), the majority of candidates recognised the absence of a reaction force gave the sensation of weightlessness. 'Reaction force = weight' so the skydiver reaches terminal velocity and feels weightless was a common incorrect response.

Most candidates recognised that viscosity is a measurement of the resistance to fluid flow in part (c) (ii). Many went on to describe the effects of viscosity and gained a second mark. Those failing to mention fluid were penalised as were those simply referring to the free-fall situation in part (b).

A correct variant of 'Pa s' was common in part (c)(ii) but many candidates, having correctly rearranged the Stokes' law equation, did not convert $N/(m^2s^1)$ into $N\,s\,m^2$. Many answers were poorly set out.

In part (c)(iii), most candidates recognised that Stokes' law applies to small spherical objects. Some had difficulty in expressing this talking about circles (or even cylinders) and it was common to say that the skydiver did not have a constant radius – which is not the same as saying that it is not spherical since circles and cylinders have constant radii too. Many candidates believed that the object needs to be at the terminal velocity for the Stokes' law force to apply – it is simply that this is when the viscous force (+ any upthrust) is equal to the weight of the falling object.

Question 2

Although most candidates were able to arrive at a value of 1.25×10^{14} J, many answers to part (a) (i) were unconvincing with squaring, minus signs and additional masses being ignored or added to, apparently, fit the numbers. Those candidates, of which there were many, who used *mgh* to calculate the potential energy on the surface of the Earth gained no credit – even though the numerical answer came out correctly if the radius of the Earth was used for *h*. The equation is inappropriate except close to the Earth's surface when the surface of the Earth is taken as a local zero of potential energy.

In part (a) (ii), many candidates knew that the gravitational potential energy at infinity is defined as being zero; few however could explain that this meant that the system lost energy by doing work in moving the shuttle to the Earth's surface meaning that the gpe would be negative. There was much confusion shown regarding the nature of gpe – many argued that it was a vector; many scripts showed confusion between force, potential and potential energy with these quantities being used almost interchangeably.

Most candidates correctly added the height of the shuttle's orbit to the radius of the Earth to gain at least some credit for part (b) (i); many did not go on to gain the full two marks by not performing the calculation correctly or else forgetting the negative sign for the potential energy.

For part (b) (ii), many argued that the gravitational potential energy was decreasing because the magnitude of the second value was the smaller. Candidates answering that the gravitational potential energy increases with height gained some credit but it was expected that they would explain how this increase in gravitational potential energy came about – this could have been equally well argued in terms of reaching the orbit from infinity (or travelling from the orbit to infinity) or from the Earth's surface. The best answers here were excellent.

Although part (c) (i) was well answered, many candidates did not realise that 'name' means just that and time spent explaining the function of the components of a rocket was time wasted. Examiners simply expected a list of features. Of the main features, the payload was frequently forgotten and no credit was awarded for the word 'propellant' there was credit for fuel, fuel tank, oxidant, oxidant tank or named propellants.

Part (c) (ii) was intended to be answered as extended prose and was completed with variable levels of success. Spelling of technical terms was often poor and explanation too frequently unstructured as candidates moved from momentum aspects to combustion aspects and back. Most candidates were appreciative of the requirement of combustion although many talked as if the reactants were being ejected rather than the exhaust gases. Understanding of the law of conservation of momentum was variable and there was considerable confusion between this law and Newton's third law. It was common place for candidates to suggest that the rocket is propelled because of the reaction of the Earth's surface on the rocket.

Many candidates did not focus on the launch aspect of part (c) (iii) and answered relating to later times in the rocket's overall journey. The key issue was that the mass of the rocket is great and needs fuel for lift off but the fuel adds to the total mass of the rocket reducing the payload to mass ratio. If was clear from several answers that a number of candidates are unclear regarding what the payload actually is.

Question 3

Answers to part (a) (i) were somewhat polarised; either completely correct or very limited. Less able candidates often did little more than to divide the weight of the ring by 8. There was considerable confusion in calculating the angle with several candidates using sine or cosine without first calculating the hypotenuse of the triangle. A handful of candidates correctly calculated the 'total' tension and then divided by 2 rather than the correct 4. Use of significant figures was generally good and few quoted answers other than two or three digits.

For part (a) (ii), many candidates believed that spinning the ring would not change the tension in the rope, ignoring the need for the tension in the rope to provide the centripetal force. The addition of the required centripetal force causes the tension to increase. Too frequently candidates simply said that the tension would change rather than increase.

Most candidates managed to obtain a correct value of force in part (b), either by using the angular frequency of linear velocity form of the centripetal force equation. Failing to square the angular frequency or velocity was fairly common and several candidates used a mass other than 22 kg. However, this was a well answered question in general.

There was considerable confusion regarding the centripetal force in part (c). Many thought that the centripetal force was not large enough to hold the children in; others that the centripetal force was forcing the children either outwards or at a tangent to the circle. It was clear that most candidates thought that the centripetal force holds the children in rather than that friction provided the centripetal force needed to remain in the circle. Many candidates talked about needing a force to counteract the centripetal force which would be trying to throw them off the roundabout.

In part (d) (i), the concept of moment of inertia was not generally well understood – many candidates recognised that it is angular analogue of mass in linear motion but it was insufficient to state that it is angular mass. Quoting the ratio of the torque per unit angular acceleration was sufficient to gain one mark but torque over acceleration was not acceptable and quite common place. Few referred to it being related to the distribution of mass about an axis of rotation.

Part (d) (ii) was answered either very well or else very poorly. Candidates calculating the angular acceleration correctly usually went on to find the correct torque. In a ‘show that’ question like this, it is not expected that candidates will write the linear analogies of the angular equations and gain credit; several candidates did this.

In part (d) (iii), linear versions were condoned and most candidates calculated the new time correctly. Many forgot to subtract the original time to gain the change. As in the previous part this was either well or cursorily done.

Question 4

Few candidates were able to state Faraday’s laws of electromagnetic induction in part (a) (i). Answers were often vague and referred to specific instances of for example coils being cut by ‘magnets’. Other candidates did not say what was cutting the flux.

Again, in part (a) (ii) the statement of Lenz’s law was not well known. Candidates often tried to paraphrase the law in a specific instance. The concept of an induced current rather than emf was condoned provided the remainder of the definition was accurately stated.

Part (a) (iii) was not well done and missed out by many candidates. Few were able to apply the laws of electromagnetic induction. Of those attempting to answer the question several did not really apply the laws to the situation. Credit was gained by those who recognised that the transmitting coil produces a varying magnetic field which interacts with the metal object; this induces an emf in the object which in turn causes eddy currents in the solid conductor. The direction of the eddy currents is such that they set up magnetic fields which oppose the changing magnetic flux originally inducing the emf.

In part (a) (iv), most candidates appeared to understand the issue involved but answers from a good number were too vague to be credited. Many thought that eddy currents were being induced in the receiving coil – eddy currents can only be induced in solid metal objects not in coils.

A surprising number of candidates did not get part (b) (i) correct. Most used the frequency/period relationship but the microsecond aspect meant there were many incorrect powers of 10 – confusion with nanosecond and millisecond being the most common.

Although there were some very clearly set out and correct answers to part (b) (ii), most candidates presented a jumble of equations and numbers that were difficult to interpret. The most common mistake was to incorrectly calculate the area of the coil; either by using the wrong power of 10 or else by using the diameter rather than the radius. It was disappointing to see candidates using the wrong formula for area when it is provided in the data booklet. It was clear that many candidates though that 24 mT s^{-1} was the rate of change of flux rather than flux density.

In part (c), most candidates suggested at least one instance of metal detection relating to national or international security. Instances relating to metal detection on a local scale were not condoned.

Question 5

For part (a) (i), most candidates recognised that the curve should be below the one given and many realised that the characteristic spectra should be in the same position for both curves; often it was very difficult to judge whether the spectra were in line due to poor draftsmanship.

The topic in part (a) (ii) was well known by very few candidates. Most thought that photons excited electrons to a higher energy level from which they fell back to the lower one emitting the energy difference as a photon.

Many candidates gained full marks for part (b) (i); although a significant number missed it out altogether. Most candidates were able to equate eV to $\frac{1}{2}mv^2$ but several failed to multiply the pd by the electronic charge before equating to the kinetic energy. Candidates would be advised to write equations before substituting values in order to avoid failing to gain any compensation marks when the final answer is incorrect.

The calculation in part (b) (ii) was completed by a small minority of candidates and there were many omissions. Few utilised $P = IV$ and many thought that the power should be multiplied by 0.4 or 0.6 rather than the correct 0.994. The answer should have been given to two significant figures but two or three were condoned in this instant; with answers written as 11000 being taken as being five significant figures unless the candidate stated that the answer was to two significant figures (the clear way to represent the answer as two significant figures is 1.1×10^4 (W)). Many candidates quoted answers to far more than three significant figures, despite the prompt in the question.

In part (c), most candidates demonstrated that they understood what a contrast medium is and what is used for in X-radiography. The best answers were very clear and detailed, outlining how the contrast medium allow medical professionals to differentiate between the images of tissues and organs of similar densities.

Question 6

In part (a) (i), most candidates calculated the maximum velocity by measuring the amplitude and period from the graph and then using the equation $v_{max}=2\pi fA$. Equally valid was measuring the gradient of the tangent to the curve at zero displacement – this was completed successfully by many; those choosing a poor tangent, small gradient triangle or just points on the graph were penalised.

Part (a)(ii) was well done by many candidates using the equation $a_{max}=(2\pi f)^2A$. Errors carried forward from the previous part were not penalised.

For part (b) a pleasing number of candidates recognised that pulses of force should be applied at time corresponding to maximum displacements. The direction of the pulses was ignored in this instance.

In part (c)(i), most candidates recognised that an external force needs to be applied to an oscillating system to cause a forced oscillation; less well known was the need for it to be period and that it did not need not be at the resonant frequency to be a forced oscillation.

Although the conditions for resonance were clearly well known many answers to part (c)(ii) were vague and did not state that an external driving oscillation needs to be applied at the natural frequency of the driven system. Increased amplitude was accepted as maximum amplitude.

Part (c)(iii) was generally answered well with most candidates recognising that the body position must be shifted synchronously with the natural frequency of the swing.

Mark Ranges and Award of Grades

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