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Physics A PHYA2

(Specification 2450)

Unit 2: Mechanics, materials and waves

Report on the Examination

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General Comments

This paper provided opportunities for candidates to demonstrate their knowledge and understanding across a wide range of the topics detailed in the specification for the Mechanics, Materials and Waves unit.

There was evidence that many candidates were better prepared compared to previous papers. Calculations were laid out in a neat and methodical manner; in written responses there was more awareness of the level of detail required. Basic definitions that had been previously examined were learned thoroughly. However, there was still a lack of awareness of the appropriate number of significant figures required.

The paper proved less demanding than previous PHYA2 examinations. Several of the questions were set within contexts that demanded careful interpretation and application of knowledge as required by the specification. There was an even balance between questions requiring written responses and those requiring calculation, with roughly half the marks associated with each. The most successful candidates were able to perform well on both types of question.

As usual the majority of candidates coped well with calculations and failed to gain marks on their written responses. The few areas that had not been examined before under this specification tended to be done poorly. However, every part of the specification has now been examined at least once so the bank of past papers will be an invaluable resource for revision and teaching.

Many candidates performed very well on this paper and produced impressive responses. The comments below will focus mainly on the common incorrect responses as this will help teachers quickly pinpoint areas for improvement.

Question 1

Part (a)(i) was rudimentary for an AS Physics candidate and most knew that the correct answer was 'the gradient'. The most common incorrect answers were 'area' or 'the line'.

In part (a)(ii), a significant number of candidates drew a **speed**-time graph with the 'speed' decreasing up to t_1 and then a line sloping upwards to a maximum 'speed' at t_2. There were also many highly curved lines. However, candidates should have assumed that acceleration was constant here. Most types of ball would not experience significant air resistance in this situation, unless thrown to a very great height, and the height shown in **Figure 1** could not be greater than about 6 metres. Candidates, who perhaps had not practiced on similar questions, struggled to visualise the situation and think it through successfully. A surprising number had the velocity of the ball falling to zero as it approached the ground or accelerating upwards after it had been thrown.

A significant number of candidates did not attempt part (b)(i), suggesting they were not sufficiently familiar with Newton's laws. Many mentioned the weight of the ball acting downwards or the ball being in equilibrium because the forces are equal. However, the force from the ball acting down on the ground is not equal to the weight because the ball is not in equilibrium. The speed would in fact be significantly greater and be determined by the speed, mass, shape and material properties of the ball. Candidates' responses also indicated that they believed the ball would be in equilibrium because it was stationary at the instant shown in the diagram.

Candidates clearly thought they were giving appropriate responses to part (b)(ii). However, very few managed to pick up even one mark. Firstly, candidates did not recognise that the **forces** on the ball needed to be discussed. The correct response, 'the upward force on the ball is greater than the weight' was very rare. Many instead gave a description of the energy transfers involved.

Some stated that energy is the 'force' acting downwards. Many wrongly stated that the ground pushes up more than the ball pushes down; 'the upward force is bigger than the downward force exerted by the ball', being a typical statement. Some explained that this is because some of the downward force from the ball is 'absorbed'.

Many candidates clearly believed that the weight and the reaction force from the ground **have** to be equal and opposite. This was presumably due to a misunderstanding of Newton's 3rd law.

A significant number thought that as the ball is momentarily stationary, the forces are balanced. Some tried to explain by discussing the deformation of the ball and transfer of kinetic to potential energy. Some thought that the upward force was a combination of the reaction force and a force 'from the ball reforming to its original shape'.

Question 2

Most candidates gained full marks in part (a). A few performed a calculation using $t=s/v$, with 3.1 as the average speed. This gave a value for g twice the required size.

In part (b) correct answers should have included 'weight is proportional to the mass and $W/m=g$', or 'doubling the mass will double the weight and g will remain the same' or similar. Many said increasing m will increase W but this was not sufficient for the mark.

A large majority of candidates seemed to be familiar with the use of a light-gate to measure velocity in part (c). Most said that air resistance would affect the ball more. However, very few then went on to explain that the increased air resistance would reduce the acceleration. Many said that air resistance 'slows down' the ball. They may be thinking, incorrectly, that the ball slows down as it falls, or they may be indicating that the ball is slower than it would be if there were no air resistance. Students therefore need to be able to describe the motion of an object in an unambiguous manner, eg 'when an object falls, the acceleration decreases due to air resistance'.

Few candidates were able to explain that the full diameter of the ball was unlikely to pass through the beam. This is a difficult idea to express. Candidates should be encouraged to include a simple sketch to help illustrate a point if they are finding it difficult to put into words. Some said that that there is more uncertainty in the measurement of the diameter of the ball. However, this would depend on the measurement technique, so credit could not be given.

Question 3

Part (a)(i) was answered correctly by a very high proportion of candidates.

Another straight-forward question followed with part (a)(ii); incorrect or missing units accounted for most of the lost marks. 'Pa' and 'Nm' were frequently quoted wrong units. Inappropriate use of 9.81 for acceleration was also seen.

There were very few mistakes in part (a)(iii), apart from the occasional use of $s = vt = 58 \times 3.5$ instead of using '*suvat'*.

Candidates found part (a)(iv) tricky, with many using $P=Fv$ with v as the **final** velocity rather than the average. This would give twice the average power. Many candidates found 20% of the power output and didn't realise that the power output is 20% of the input power and they should therefore multiply by five rather than divide.

A surprisingly number of candidates made no attempt at part (b) because they did not know where to start. Most of those candidates who knew how to approach the question, gained full marks. The use of '*suvat'* could only gain two marks out of three. Marks were often lost here due to arithmetic errors in calculations; typically, forgetting to square the speed.

Question 4

Very few candidates knew the definition in part (a)(i). Many gave a vague description of a *couple*. Most simply defined a *moment* and these responses received no credit.

Despite not having known the definition of a moment of a couple, many went on to successfully calculate it in part (a)(ii). A few calculated 810 × d/2, instead of simply 810 × d. A significant number of candidates dropped marks by giving incorrect units. Typical errors were: N, Nm^{-1}, NM , and nm.

Many candidates got the calculation correct in part (b) though some did not multiply by two to take in to account the two horses. A significant number wrongly multiplied the torque (instead of the power) by the velocity to get 5400. A significant figure mark was applied to this question and a significant amount of candidates did not round to two significant figures; needlessly losing one mark.

Many candidates came up with very sensible answers in part (c). The question examined assessment objectives AO3 *How Science Works*. This requires that candidates 'analyse and evaluate scientific knowledge and processes'. Therefore, the question required a little bit of thinking around science. Very few candidates missed the question out. Many understood that a comparison was being made between steam engines and horses due to the widespread familiarity with the capabilities of the horse at that time.

Question 5

In part (a) relatively few candidates knew that the frequency remains constant when refraction takes place.

Most drew the ray very well in answer to part (b) and the widespread use of a ruler showed a significant improvement over similar questions in previous examinations. However, a large number did not attempt the question. Those who dropped one mark tended to do so because their ray had a reflected angle that was far too big. Though it is not necessary to use a protractor to gain this accuracy mark, it should be encouraged for those who find it hard to make a good approximation by eye.

Part (d) was a little bit more difficult than previous, similar questions in that the angle of refraction had to be calculated (90 – 80.4 = 9.6°) prior to finding the incident angle. This confused a large number of candidates. Among those who did know what to do, a surprisingly common error was to use 100° for a right angle rather than 90°.

Candidates tended to focus on **one** cause of loss in answer to part (e), either 'multipath dispersion' or 'attenuation due to energy loss from the pulse'. This meant they accessed only one of the two marks available. Some guesswork was evident in responses to this question. Some candidates explained that the pulse had its amplitude reduced and length increased in order to fit inside the narrow fibre – 'the fibre is too thin to let the high amplitude through' was a typical answer. Other common responses were that the wavelength increased when the light entered the glass (presumably the pulse was interpreted as a waveform) or the lower speed of light in glass caused the broadening effect.

Question 6

In part (a), suitable scales were chosen by nearly all candidates and points were plotted very accurately by all but a few. From knowledge of material properties, it is sensible to assume that the first section of the graph should be a straight line. However, many candidates drew a curve for the first part. After this, any suitable best fit line was accepted if it was smooth.

Part (b) was generally done very well, with most choosing points on their line correctly and using suitably large values. A few candidates wrongly used the ultimate tensile stress divided by the corresponding strain.

Most candidates were very successful on the calculation in part (c). The main problem was arithmetic errors and mistakes on powers on ten. It is a good idea to make even high ability students practice plenty of these questions when revising.

Question 7

Part (a), an extended answer question, yielded the highest marks of any so far on this examination. It was a standard situation and candidates were very familiar with the physics so, the majority gained more than half marks. It was not too difficult to get five marks out of six however; full marks were only given to the most complete of responses.

It was pleasing that only a few misinterpreted the question and chose the wrong path; inappropriate discussion of 'gratings' was only seen a few times. The majority of candidates still recommend protecting the eyes from laser radiation by wearing 'goggles'. If the candidate insists on giving this advice, they must specify 'goggles designed to protect the eyes from laser radiation' or words to that effect, since ordinary lab goggles would provide no protection.

Marks were still sometimes lost due to candidates not specifying measuring instruments. However, there was a marked improvement on previous experimental description questions. Even the humble 'ruler' should be specified if it is to be used.

Part (b) was a common question and perhaps, therefore, it should have yielded a higher percentage of full-marks answers. The most common error was to say that the two sources are 'in phase'. However, it should be stressed that coherent sources have a **fixed phase relationship**, so they are not necessarily **in** phase.

Many candidates did not include the single slit and many did not label the slits in answer to part (c). A significant number did not attempt the question at all. Surprisingly, less than half scored any marks at all on this question.

In part (d), some candidates thought that the fringes for white light would be further apart. This would only be true if the laser were red; the candidate would have to state this assumption to gain the mark. Some lost marks because they did not make it clear which light source they were referring to.

Most candidates gained the mark in part (e) for mentioning destructive interference but did not go on to explain that the cancellation is caused by the waves meeting in antiphase or with half a wavelength path difference.

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