Examiners' Report
Principal Examiner Feedback

January 2020

Pearson Edexcel International Advance Subsidiary Level In Physics (WPH11) Paper 01 Mechanics and Materials

Introduction

This paper was concerned with the physics of forces, including gravitational forces, tension, and forces in fluids due to drag and up-thrust as well as the effects of forces on the motion of objects in one and two dimensions. The effects of forces on the shape and structure of the materials of which the objects are made was also examined, and students were expected to apply abstract principles of mechanics to contexts they should have studied as well as new or more unfamiliar contexts.

On the whole, students showed good ability in the more basic applications and simple recall questions and were able to deploy a good range of different strategies to solve problems where there were a variety of possible approaches, such as in **Q11**, **Q15 (c)**, and **Q16 (a)(ii)**. Where explanations were required it was very common for students to miss key mark-bearing points, a particular example being **Q19 (b)(i)** where the directions of forces were often stated but not which object were exerting the forces.

Students' shown working often lacked precision, and there were many cases where marks could have been awarded if the student had simply told us what a symbol stood for, or of which quantity a written number was supposed to be the value. Units are only required for a final answer, but including a unit in an intermediate step can often help identify the quantity. A careful reading of a question is also invaluable in gaining marks, and a good example of this was **Q14**, where many students misread the question to mean that they needed to explain how the glue worked, rather than how it changed the properties of the concrete, all of which could be deduced from reading the graph.

The standard of English in nearly all papers was very good.

Comments on Individual Items

I. Multiple Choice

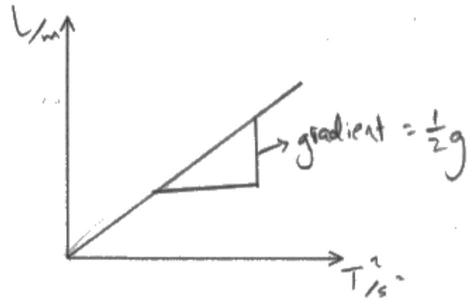
	Subject	Correct response	Comment
1	Units	C	This could be solved by writing out the formula for each quantity.
2	Gravitational Field Strength	B	The definition needs to be learnt.
3	Addition of Vectors	B	This question tests a mathematical skill.
4	Newton II	D	The resultant force must be non-zero, and downwards.
5	v – t graphs	D	Final displacement is total area, with area below t-axis counting negative.
6	Impulse	A	The collision happens after $t = 0$ so the time cannot be negative.
7	Momentum	D	A and B can never be true by Newton's Third Law, final speed is ½*v.*
8	Efficiency	D	Dimensionally only C and D are possible, mathematical skill required.
9	F – x graph	C	The identities of the three points need to be learned.
10	Viscosity	A	If the acceleration is decreasing then so is the resultant force.

II. Written Responses

Question 11

This question tested the student's ability to describe a simple experiment to measure "g" by ball-bearing drop. The classic and easiest way to do this is to realise that the drop time is √(2*gl*) and to plot a graph of 2*l vs.* t^2 for a gradient of *g.* The student needed to explain that the equation $s = ut + \frac{1}{2}at^2$ can be used if $u = 0$ and to describe how to plot and use the graph to obtain the desired result. As the question specifically mentioned that *g* should be in m s^{-2} it was important that units were quoted somewhere in the answer, and many students failed to gain the mark for specifying units.

There are a number of different ways of plotting a graph to give a straight line from which *g* can be deduced, and credit was given for any method that worked. Greater familiarity with this experiment would enable students not to have to make up methods on the spot.
I would also draw attention to the necessity of defining any symbol used in an answer which is not given in the question. A very common error was to label the "*l* " axis as "*s*", without identifying the magnitude of the final displacement with the drop height, thereby failing to score the mark for axis labels. Very few students scored full marks this item.
This example below is a response which scored all five marks.



Release the ball and start the timer, ~~get~~ sustitute the measurements given in the equation $s = \frac{1}{2}gt^2$ as $u=0$, repeat the experiments for different values of L and get more measurements of g using the same equation, draw a table of the values and the plot a graph of L on the y axis against t^2 on the x axis. according to the equation of $s = \frac{1}{2}gt^2$ which is in the form $y = mx$ ~~a~~ the points must be plotted and a line of best fit drawn, the gradient G of the line will be $\frac{1}{2}g$ so $g = 2G$

Question 12 (a)

The other condition for the applicability of Stokes' Law beyond the object being spherical is that the flow around the sphere should be laminar, that is, not turbulent. We also accepted "slow" as an answer. Many of the students who failed to score this mark referred to "terminal velocity" as a condition, which is incorrect as terminal velocity may be both turbulent or laminar.

Question 12 (b)

In order for Stokes' Law to be applicable the forces required for terminal velocity should be calculable from Stokes' Law. The expected method was to calculate the drag force required and the drag force available from Stokes' Law and to show that the force calculated from Stokes' Law is insufficient in this circumstance. There were also several other approaches, such as to calculated the velocity required for Stokes' Law to give the right drag force. Many students performed the correct calculation but failed to gain the final mark by neglecting to explain how the numbers showed that Stokes' Law was not applicable.

The response below is a good example of an answer that scored all five marks.

$F = 6\pi\eta rv$

$\frac{d}{2} = r$

$\frac{6.0\times10^{-3}}{2} = 3.0\times10^{-3}\,m$

$F = 6\pi \times 8.9\times10^{-4} \times 3.0\times10^{-3} \times 0.5$

$= 2.5164157 \times10^{-5}\,N$

$W = U + F$

$9.1\times10^{-4} \times 9.81 = 1.1\times10^{-3} + F$

$F = (9.1\times10^{-4} \times 9.81) - 1.1\times10^{-3}$

$F = 7.8271 \times10^{-3}\,N$

No we cannot use Stokes's Law because drag force obtained was less than one expected.

Question 13 (a)

The definition of centre of gravity is a matter of learning the words. Many students clearly had a very hazy idea about this concept, imagining that the mass of the object actually was concentrated at the centre of gravity rather than being an average. The response below is a good example of what we were looking for.

(1)

Centre of gravity of an object is the point where its weight appears to act

Question 13 (b)

The graph is actually a concave graph that starts at half the weight and ends at all the weight. Very few students started the graph at half the weight, most simply had a graph with a positive gradient, scoring just one mark.

Question 13 (c)

Two points needed to be made here, firstly that the centre of gravity of the book was no longer above the shelf when *x* > *l/2* and secondly that in that situation there would be a net clockwise moment acting on the book. The phrasing of many answers showed a lack of precision in students' use of physics terms. The answer below, although clumsily presented, scored both marks.

The center of gravity will exceed the length of the shelf, so the line of action of weight will be to the right ~~(ie not in line)~~ of (ie not in line) with the contact force. will produce a net

down

moment, so net force, will fall off.

clockwise

Question 14

In this question many students interpreted the word “how” to mean that they needed to describe *why* the addition of glue changed the properties of the concrete. The question actually asked students to describe the changes in the properties caused by the addition of the glue, and was thus an exercise in reading the graph shown, the properties that changed being stiffness, UTS and toughness. The question was not well answered on the whole, hardly any students scored full marks. The response shown below scored four marks as UTS, stiffness and toughness are all addressed, and reasons given for changes in toughness and stiffness, scoring five for indicative content = 4 marks. The linkage mark was not awarded due to confusion between Young modulus and strength.

adding capsules to the concrete changes the properties by making it more stronger. As seen on the graph the gradient of the sample B increases as it contains glue which shows it has a large young modulus. more over sample B has greater energy absorbtion which reinfores the crack and allows it to be more ductile, this is shown on the graph as Sample B has a larger area underneath the graph, the sample B can undergo tensile and compressive forces which is seen by the large incline, it doesnt reach its breaking point nor it reaches it's yield and deformed point further proving the concrete with glue is stronger and more tough than sample A. Sample A on the other hand has a low young modulus meaning it can break easily as it is more brittle as shown by the low and short gradient.

Question 15 (a)

The projectiles question was set on an inclined plane, but the first part was a “show that” to calculate the initial velocity for the final part. Again, as in Q11, the condition that u = 0 in the equation $v^2 = u^2 + 2as$ needed to be stated as well as showing that the “show that” value was on rounded from a result calculated to more significant figures, in this case 3.4(3103) m s^{-1}. This was a well-answered question with a very high proportion of students scoring both marks. The response show below is a typical two mark answer.

$s = \cancel{ut + \frac{1}{2}at^2}$ $\quad v^2 = u^2 + 2as$

$s = \frac{1}{2}at^2$ $\quad v^2 = 0^2 + 2 \times 9.81 \times 0.60$

$v^2 = 11.772$

$\boxed{v = 3.4\ m\,s^{-1}}$

Question 15 (b)

A surprising number of students failed to score both marks in what is a very simple resolution of vectors problem. The most common mistake was to use an undefined symbol for velocity or else to muddle the sines with the cosines. Just over half of students scored both marks. The example below scores both marks as 3.43 is the velocity shown in **15(a)**.

(2)

Horizontal component = $3.43 \times \sin 70^\circ$

Vertical component = $3.43 \times \cos 70^\circ$

Question 15 (c)

To show that the ball did not bounce a second time could be done by showing that it hits the ground after the end of the ramp, that it is still airborne at the point where the ramp ends, or that its velocity is too great to land short of the end of the ramp. All three methods were seen and where executed correctly were given full credit. Students should be encouraged to use the simplest method in this problem, so greater practice with different geometries should be encouraged. Many set out to show that the distance along had to be cleared and ended up trying to resolve parallel and perpendicular components of accelerated velocity, nearly always resulting in no marks. Another common error was to calculate the time taken for the projectile to return to its initial height (0.24 s) and call that the time to the end of the ramp, neglecting the extra time needed to reach the ground. Just over half of students ended up with no marks for this item, the few who scored most highly tended to use the first method, time to clear the ramp = 1.23 / 3.4 sin 70˚ = 0.38 s, so drop = – 0.38 ×3.4 cos 70˚ + ½ × 9.81 × 0.38^2 = 0.27, less than 0.86 so doesn't hit the ground, nor the ramp.

(4)

$t = \frac{X_H}{V_H} = \frac{1.23\,m}{3.2\,m/s} = \cancel{0.34}\ 0.384\,s$

$X_V = ut + \frac{1}{2}at^2$

$= 1.2\,m/s \times 0.384\,s - \frac{1}{2} \times 9.81\,m/s^2 \times (0.384\,s)^2$

$= -0.26\,m < -0.86\,m.$

So the ball does ~~will~~ not bounce a second time on the ramp.

Question 16 (a) (i)

This was a simple matter of measuring the distance on the paper and dividing it by the distance measured for the centimetre to get the height. Many students used the given time and equations of motion, which also gave a correct answer of 3.4 cm. A lot of students' measurements were outside tolerance, and others failed to use the scaling correctly.

Question 16 (a) (ii)

There are a great variety of different methods for solving this vertical projectile problem, particularly as there was redundancy in the information given. The initial speed could be calculated from the measure height alone, and also from the given time, or a combination of the two. Accordingly this question was generally very well answered with a good number of students scoring full marks. The example below shows the use of only the measured height, and scores all the marks.

(3)

~~Pa~~ $v^2 = u^2 + 2as \qquad v=0$

$0 = u^2 - 2(9.81)(0.0335)$

$0 = u^2 - 0.65727$

$\sqrt{0.65727} = u$

$u = 0.8107\,ms^{-1}$

Initial speed = $0.811\,ms^{-1}$

Question 16 (b)

Most students were able to work out the mass of steam ejected but there was much confusion over how conservation of momentum should be applied to this problem. The simple way to solve the problem is to say that if the ratio of the masses is 14:86, then the ratio of speeds is 86:14, giving a recoil speed of 86 × 1.5 ÷ 14 = 9.2 m s^{-1}. Marking points were for the mass of steam/water, application of the definition of momentum and use of conservation of momentum, plus correct answer with unit. Many students scored only one mark, generally for calculating the mass of steam correctly. The example below shows all four marking points.

(4)

When steam is ejected, the mass of ~~peped~~ popped pop corn becomes
$0.11 \times (1-14\%) = 0.0946g$

Apply the principle of conservation of momentum:

The initial momentum of the unpopped ~~popped~~ ~~popco~~ kernel is 0, so without external forces, the sum of momenta in popped kernel and ejected steam is 0

The momentum in the popped kernel is $0.0946 \times 1.5 = \cancel{0.0477}\ 0.1419\ N \cdot s^{-1}$

Since the steam moves in opposite direction,
the momentum for the steam is $0 - 0.1419 = -0.1419\ N \cdot s^{-1}$,

Hence its velocity $= \dfrac{-0.1419}{0.11 \times 14\%} \approx -9.21\ m \cdot s^{-1}$ (2d.p.)

speed $= 9.21\ m \cdot s^{-1}$ (2d.p.)

Speed = $9.21\ m \cdot s^{-1}$

Question 17 (a) (i)

This question tested students' ability to equate initial elastic potential energy with final kinetic energy, and needed students to work out (or recall from previous experience) the relationship between extension and energy in an elastic material. It was rare to see a completely satisfactory explanation for the straight line, many students seeming to thing that a bald application of Hooke's Law was enough. Many students scored zero marks for this question. The response below scores full marks.

(4)

$E_{el} = \cancel{\frac{1}{2}k} \ \frac{1}{2}k(\Delta x)^2$

$E_K = \frac{1}{2}mv^2$ $\qquad E_{el} = E_K$

And k, mass is constant.

so $x^2 \propto v^2$

$x \propto v$

So the graph should be a straight line.

Question 17 (a) (ii)

It was far more common for students to use two points from the graph to determine the spring constant than to actually calculate a gradient. This is fine if the line clearly goes through the origin, as this one does, but is a dangerous practice in general. The response below is typical of a three mark answer. Many of students failed to score any marks for this item.

At Δx of 0.5m $\quad v = 4.4\,m\,s^{-1}$

Elastic strain energy in cord = KE of glider = $\frac{1}{2}K(\Delta x)^2$

$\cancel{\frac{1}{2} \times 0.3 \times}$ $\frac{1}{2}mv^2 = \frac{1}{2}K(\Delta x)^2$

$\frac{1}{2} \times 0.3 \times (4.4)^2 = \frac{1}{2} \times K (0.5)^2$

$\frac{2 \times 2.904}{(0.5)^2} = \frac{1}{2}K(0.5)^2 \ \frac{\times 2}{(0.5)^2}$

$\boxed{K = 23.2\ N m^{-1}}$

$k =$ 23.2 $N m^{-1}$

Question 17 (b)

To score full marks in this question the relationship between Hooke's Law and proportionality needed to be clearly stated. The most common error was to conflate proportionality with elastic limit. Answers purely in terms of elasticity were given no credit. The majority of students scored at least one mark for this question, a minority scoring both marks, as does the response below.

Since the extension is already passing over limit of proportionality; ~~s~~ the ~~p~~ structure of the elastic cord is distorted, and the particles arrangement is broken down, and No longer obeys hook's Law.

Question 18 (a)

This question was simply a definition. Students should be aware that the definition is in the formula sheet, so merely quoting the formula gains no marks unless the terms in the formula are fully explained. Stating that Young modulus is a measure of stiffness was not enough to score the mark.

Question 18 (b) (i)

Students should be wary of seeing anomalies were there are none. All four values of diameter were required for the mean. On the whole this question was answered well, although the mark for the final answer was often missed through confusion over units.
The example below scored all three marks.

(3)

$\frac{1}{4} \times (0.230 + 0.235 + 0.230 + 0.240)$

$= 0.234\ mm.$

$0.234\ mm = 2.34 \times 10^{-4} m.$

$A = \frac{1}{4}\pi d^2 = \frac{\pi}{4}(2.34 \times 10^{-4} m)^2 = 4.3 \times 10^{-8} m^2$

Cross-sectional area = $4.3 \times 10^{-8} m^2$.

Question 18 (b) (ii)

This question asked students to use a given value of a gradient to determine a Young modulus. Many students were confused by this and unable to substitute the mass and extension correctly into the formula, although there were many good answers. Failure to multiply by *g* was a common reason for not gaining the final mark.

(3)

from gradient $\frac{m}{\Delta x} = 195\ kg\ m^{-1} \rightarrow m = 195\,\Delta x$, if $\Delta x = 0.05m$

$m = 195 \times 0.05 = 9.75\ kg$

$F = W = mg = 95.65N$

$E = \frac{\sigma}{\varepsilon} \rightarrow E = \frac{Fx}{A\Delta x} = \frac{95.65 \times 3.5}{4.3\times10^{-8} \times 0.05} = 1.55\times10^{11}\ Pa$

Young modulus = 1.6×10^{11} Pa

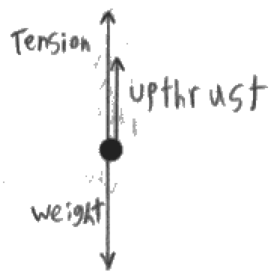
Question 18 (b) (iii)

A disappointingly large number of students were unaware that Young modulus is a material property and is therefore unaffected by the size nor shape of the specimen. Only a very few students were able to score both marks.

the extension will be less thus the graph will have a (~~steeper~~ greater gradient, and the Young modulus will stay the same be cause the strain is unchanged

Question 19 (a)

The free body diagram question was generally answered very well, those students who did not score full marks were often those who were not paying attention and confused the situation with a Stokes' Law question, labelling a drag force rather than an up-thrust, or adding an extra spurious drag force. Lines needed to be vertical, and to touch the dot, as shown in the example below.



Question 19 (b) (i)

Newton's Third Law traditionally causes a great deal of confusion for students, and very few students scored full marks for this question. An answer to any Third Law question must state which object is exerting the force and which the force acts on. This question is about the reaction force of the ball on the water *caused by* the upward up-thrust force of the water on the ball. This extra force on the water is what causes the increase in the balance reading. The example below scores the first two marks but only just manages to score the final mark relating to the balance reading.

~~th~~ ~~The ball gives o~~ Water gives upthrust to the ball.
So the ball gives an equal and opposite force ~~the~~ to the water.
So the water's "apparent weight" is larger.
the data reading on the balance is the pressure that water gives. It's equal and opposite to the support force that the balance gives to ~~t~~ water.

Question 19 (b) (ii)

Unless a student scores full marks it is very important in shown working that quantities are carefully labelled. For example, simply writing 0.150 somewhere in the script scores no mark as the examiner has no way of knowing whether the student intends this to be the volume or mass of either the sphere or the water. A good number of students scored full marks on this relatively simple question, and many scored less than they should have done due to careless working. The example shown below is an excellent response that very clearly scores all the marks.

mass of water displaced = 0.15 kg

volume of water displaced = 0.15 ÷ 1000 $kg\,m^{-3}$ = $1.5 \times 10^{-4}\ m^3$

mass of sphere = $\rho \times V$ = 2000 $kg\,m^{-3}$ × $1.5 \times 10^{-4}\ m^3$

mass = 0.3 kg

Mass of sphere = 0.3 kg

Question 19 (b) (iii)

This question was a further test of a student's understanding of Archimedes' Principle, and a disappointingly large number of students scored no marks for this item. Many failed to realise that oil being less dense than water means that the weight of fluid displaced is less for the same volume.

The response below is typical of a two mark response, the first mark for the reduction in up-thrust and the second for the effect on the reading.

The volume displaced by the sphere is the same, however as the oil is a lower density than less mass of the oil is displaced, so there is less upthrust and so a lower increase on the balance, and it will be less than 0.465 kg.

Concluding Remarks

The paper allowed many students to show high levels of aptitude and knowledge in physics and it was very encouraging to see some of the excellent examples of imaginative and elegant solutions some students presented, especially in the projectile questions.

It was also clear in general that more familiarity with the core practical activities would be beneficial to students as these contexts will occur frequently in examinations. A feel for the expected magnitude of the Young Modulus for a metal, for example, would help students to know whether their value was plausible.

Students should be encouraged to annotate calculations more clearly to help both themselves and others to follow an argument or calculation, particularly in the final lines where a conclusion is to be drawn.

The recommendations for improving student performance remain similar to those in previous series, namely:

- Time spent in describing and writing up core practical activities will benefit recall in an examination.
- Practice in applying principles in a wide variety of different contexts will help build confidence and initiative.
- Encouraging students to spend time in close reading of questions, and in re-reading both question and their answer will help students avoid ambiguities and contradictions.
- Learning basic definitions, and especially taking care to define quantities used, will avoid students failing to gain credit for concepts they do in fact understand.
- Annotating calculations to describe which quantities numbers refer to will make it easier for students to score marks for intermediate steps in calculations.

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