Examiners' Report
Principal Examiner Feedback

October 2022

Pearson Edexcel International Advanced Subsidiary Level in Physics (WPH11) Paper 01 Mechanics and Materials

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General Remarks

This paper was concerned with the physics of forces, including gravitational forces, tension, reaction, and forces in fluids due to drag and upthrust 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 had been well prepared for this exam and showed good ability in the more basic applications and simple recall questions such as the motorboat question **Q11**, the constantan wire **Q12** and the skaters question **Q16**. Candidates were able to deploy a good range of different strategies to solve problems where there were a variety of possible approaches, such as in the strength of the constantan wire **Q13(a)** and the ball being thrown at the wall **Q15**.

Explanations of physical phenomena were less well attempted, though better than in previous series. This was particularly evident in the balloon question **Q14(b)** where students did not clearly show to which part of the narrative their explanations referred and often failing to state whether they were referring to the initial or final stage of the motion. In **Q14(b)**, **Q16(c)**, **Q17(b)** and **19(c)** students often failed to address the main physical processes at play, though there were many good attempts. Students should be encouraged not to rush into answering questions without first reading them thoroughly.

In questions where a conclusion needed to be drawn or explained students were overall showing a comparison of a calculated result with the condition that it needed to satisfy, though some were losing the final mark by neglecting this. This applied to **Q12(a)**, **Q15(b)** and **Q16(b)**.

Final answers must be correctly rounded, not truncated, and truncated or rounded values in multi-stage calculations will not generally yield the required value for the final mark. It is advisable that students should use calculators to retain all significant figures for values carried forward and only round answers for the final line.

It was very pleasing to see the very high standard of English in many papers, though there were a significant number of papers where the candidate's command of English did not seem adequate for the demands of this paper. Many answers to **Q15(b)** correctly concluded that the ball "did not went" over the wall; "went not over the wall" would have been classier.

SECTION A

Multi-Choice Items

	Subject	Correct response	Comment
1	Velocity-time graphs	**B**	Displacement is given by the area under a velocity-time graph.
2	Scalars and vectors	**C**	Momentum is a vector quantity.
3	Stokes' law	**C**	Stokes' law applies to small spherical objects at low speeds.
4	Velocity-time graphs	**A**	Acceleration is given by the gradient of a velocity-time graph.
5	Young modulus	**C**	Young modulus is the ratio of stress to strain.
6	Force-extension graphs	**B**	Work done is the area under a force-extension graph.
7	Addition of vectors	**C**	The resultant of two vectors is the sum of the vectors.
8	Elastic strain energy	**C**	Twice the force for two thirds of the extension gives four thirds of the energy.
9	Kinetic energy	**A**	The ratio of the masses is the inverse square of the ratio of the velocities.
10	Efficiency	**C**	Energy wasted is (1 − efficiency) × total power input.

Multi-choice items were generally very well-answered, students who scored well in Section A did not necessarily always go on to score a good mark overall. Question 8 was the only question that caused candidates significant difficulty.

SECTION B

Examplar items show examples of answers which scored full marks unless otherwise stated.

Question 11 The Motorboat

11(a)

A simple statement defining a resultant force was all that was required. A surprising number of candidates were not able to provide a coherent definition, though many seemed to have the right idea. A focus on learning standard definitions would help many students.

(a) State what is meant by a resultant force.

(1)

Resultant force is a vector sum of all forces acting on a body

11(b)

Candidates were expected to apply their knowledge of Newton's second law and the idea of resultant force. It was common for candidates to use an incorrect value for resultant force due to forgetting that two unequal horizontal forces were acting on the boat.

Calculate the acceleration of the boat at this time.

mass of boat = 7.5×10^3 kg

(2)

$(\rightarrow): m \cdot a = F_{engine} - R_{drag}$

$a = \frac{F_{eng} - R_{drag}}{m} = \frac{5.5 \times 10^3 N - 3.1 \times 10^3 N}{7.5 \times 10^3 kg} = 0.32\ ms^{-2}$

Acceleration = $0.32\ ms^{-2}$

11(c)

This question required students to realise that the work done could be calculated from the force and the distance moved in one second. Many candidates attempted to calculate the kinetic energy of the boat, which is irrelevant, and a significant few did not state, or gave an incorrect, unit.

Calculate the output power of the engine.

(2)

work done $= 4.8 \times 5.5 \times 10^3$

$= 26400$ J

Power $= \frac{E}{t}$

$= \frac{26400 \text{ J}}{1 \text{ s}}$

$= 26400$ W

Output power = 26400 W

(Total for Question 11 = 5 marks)

Question 12 The Constantan Wire

12(a)

Deducing whether the wire could support the load required a comparison to be made either between stresses or tensions. This question was generally very well answered, both methods being frequently seen.

Deduce whether the wire could support a weight of 150 N.

(3)

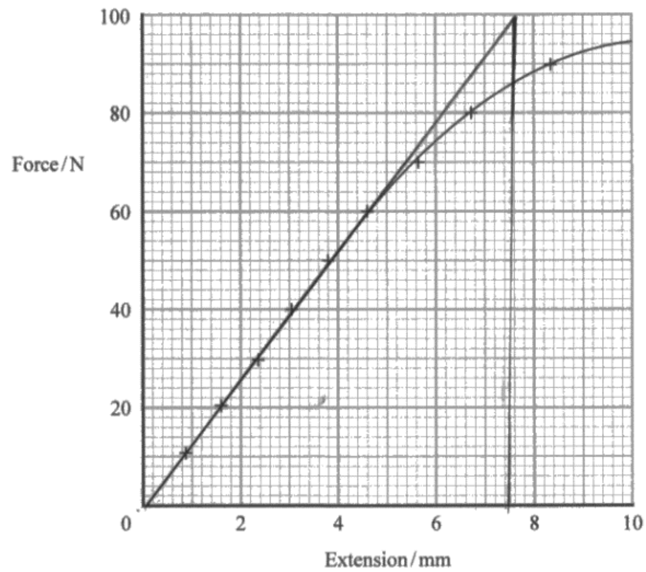
$\sigma = \frac{F}{A} = \frac{150}{3.97\times10^{-7}} = 377.8\times10^{6}$ Pa

377.8×10^{6} Pa $< 420\times10^{6}$ Pa

can support

12(b)(i)

The stiffness of the wire could be calculated almost directly from the gradient of the graph. Candidates who drew a tangent at the origin and used a large triangle could score the marks easily, many candidated did not obtain a sufficiently accurate value of the gradient to score all the marks. Greater emphasis on interpretation of graphs would improve performance in this type of question.



(i) Show that the stiffness of the wire is about 1.3×10^4 N m^{-1}.

(2)

$\Delta F = k\Delta x$ $\qquad x = 7.5$ mm $\times 10^{-3} = 7.5\times10^{-3}$ m

$k = \frac{\Delta F}{\Delta x} = \frac{100}{7.5\times10^{-3}}$

$= 13333.3$ N m^{-1}

$= 1.3\times10^{4}$ N m^{-1} (Ans).

12(b)(ii)

Getting the Young modulus form the stiffness using an equation given in the question did not prove challenging for most candidates and this question was well answered, most candidates scoring well.

Determine a value for the Young modulus of constantan using the student's data.

(2)

$k = \frac{EA}{x}$

$EA = k \times x$

$\therefore E = \frac{k \times x}{A} = \frac{1.3 \times 10^4 \times 4}{3.97 \times 10^{-7}} = 1.31 \times 10^{11}$ Pa

Young modulus = 1.31×10^{11} Pa.

(Total for Question 12 = 7 marks)

Question 13 The Wheelbarrow

13(a)

The question required candidates to give a clear account of why the vertical forces at opposite ends of the wheelbarrow were not equal. Many candidated made statements that were too vague, not mentioning which particular moments had to balance nor describing the features of the situation which led to the inequality of the forces.

On the whole though, candidates did answer this question well, and some very good accounts were seen.

(a) Explain, by considering moments about G, why *P* is less than *R*.

(3)

moment = F x perpendicular distance from pivot to the line of force.

Since it's in equilibrium, moment of R is equal to the moment of P.
and distance from R to G is ~~a~~ smaller than P.
so P is ~~±~~ Smaller than R.

13(b)

For a moments calculation it is important to know the point about which moments are being taken. A majority of candidates were able to calculate the distance correctly, but a large number missed a mark by not specifying a pivot point. Any point can be taken as a pivot point, the C of G and the wheel being the obvious ones, so a method mark for stating which one was often missed.

Determine the horizontal distance between the centre of gravity of the wheelbarrow and the centre of the wheel.

(4)

Weight of the wheelbarrow = 320+80=400 N
Take centre of wheel as a pivot.
400 x d = 80 x 1.5
∴ d = 0.3 m

Horizontal distance = 0.3 m

Question 14 The Lost Balloon

14(a)

The question was about about upthrust due to displaced air, and most candidates were able to apply this to calculate the resultant force. Those who struggled would have been helped had they drawn a free-body force diagram for themselves to clarify the situation. A number worked out the density of the balloon, which was not required.

Calculate the resultant force on the balloon immediately after it is released.

mass of balloon and string = 9.20×10^{-3} kg
volume of balloon and string = 5.00×10^{-2} m^3
density of air = 1.20 kg m^{-3}

(4)

$U = V\rho g = (5.00\times10^{-2})(1.2)(9.81) = 0.5886$ N

$W = mg = (9.2\times10^{-3})(9.81) = 0.090252$ N

Net force $= U - W$

$= 0.5886 - 0.090252$

$= 0.498$ N (3sf)

Resultant force = 0.498 N

14(b)

Most students were able to score at least three marks on this. Terminal velocity situations are commonly asked about on exams so should be sufficiently covered. In many responses, it wasn't clear whether comments were referring to the initial stage or the terminal velocity stage, so students should be advised to make it clear which point in time they are referring to in the narrative. Structuring a response into paragraphs would help with clarity.

Explain how the forces acting on the balloon affect its motion as it moves upwards from the moment it is released.

(6)

① At start of the ~~ballon~~ ballon is released, the resultant force = uptrust − weight, the acceleration is maximum, the drag force = 0, the velocity = 0.
② Then, the velocity increase, the drag force increase.
③ Due to N2, F=ma, the acceleration decrease, the resultant force decrease.
④ But the velocity of the balloon ~~sto~~ increase at a lower rate.
⑤ At last, the acceleration = 0, the resultant force = 0, the velocity reach the maximum constant terminal velocity.
⑥ In ~~the~~ this action, the motion of balloon is upwards.

Question 15 The Ball and the Wall

15(a)

This was a simple projectiles question and was well answered by the majority of candidates.

(a) Show that the ball travelled the distance to the wall in about 0.8 s.

(3)

$V_H \Rightarrow 9.7 \cos 49 = 6.364\ ms^{-1}$

Total time $= \frac{5}{6.364}$

$= 0.786\,s$ [shown]

15(b)

Most candidates were able to draw the correct conclusion from the information, there were two ways to approach this, determining that the maximum height reached was less than the height of the wall, or determining the height of the ball when it reached the position of the wall. Both methods were seen. Many candidates lost marks by neglecting units for their values of height; students should be encouraged always to give units for all physical quantities.

(b) Deduce whether or not the ball went over the wall for this attempt.

(4)

$s = \frac{(9.70 \sin 49)^2}{2(9.81)}$

$s = 2.73\,m$

The ball did not go over the wall as the maximum height the ball reached was ~~only~~ 2.73 m ~~at~~ which is less than ~~2.73m~~ the height of the wall (3 metres).

Question 16 The Skaters

16(a)

This is a very standard question which often occurs. Candidates typically failed to score the second mark by neglecting to state the condition for momentum conservation. Students should be encouraged to learn good forms of words for standard answers.

(a) State the principle of conservation of momentum.

(2)

Total momentum before the collision is equal to total momentum after the collision, provided that there's no external force acting

16(b)

This question required either the comparison of two momentums or of the expected velocity from momentum conservation with the actual velocity. Both methods were seen, and the question was generally well answered, the former method being seen more often. Marks were again missed by a neglect of units.

Deduce whether momentum is conserved in this collision.

initial speed of skater A = $5.5\,m\,s^{-1}$
mass of skater A = 65 kg
initial speed of skater B = $7.5\,m\,s^{-1}$
mass of skater B = 60 kg

(3)

$P_1 = m_B v_B + m_A v_A = 60 \times 7.5 + 65 \times 5.5 = 807.5\ (kg\,m \cdot s^{-1})$

$P_2 = (m_A + m_B)v' = (65+60) \times 6.2 = 775\ (kg\,m \cdot s^{-1})$

$\because P_1 > P_2$

$\therefore$ The momentum isn't conserved.

16(c)

This was a question about how energy is transformed and so no marks can be easily awarded without mentioning work being done. Candidates overall simply stated that energy was transformed without telling us how. Consequently, only a very few of the most well-prepared students were able to score marks in this question.

Explain the decrease in kinetic energy in this collision.

(2)

Some work is done against the friction between the two skaters, so some kinetic energy dissipitated. Therefore, the kinetic energy decreases.

Question 17 The Foraminifera

17(a)(i)

This was another Newton first/second law question, these occur frequently in this paper so students should prepare well for them. In this case it was a Stokes' law situation, and most candidates were able to score good marks in this question.

Show that the viscous drag on the foram is about 7×10^{-8} N.

(3)

17ai) at terminal velocity, ~~drag~~ drag = mg − upthrust

$drag = 1.15 \times 10^{-8} g - 4.37 \times 10^{-8}$

$= 6.91 \times 10^{-8}$ N

17(a)(ii)

The question used the result of part (a) to determine a terminal velocity. This was well answered, though many students missed the final mark by using incorrect forces or by making calculation errors.

(ii) Calculate the terminal velocity of this foram.

diameter of foram = 9.2×10^{-4} m
viscosity of seawater = 1.41×10^{-3} Pa s

(2)

$\because F = 6\pi r \eta v$, $r = 4.6 \times 10^{-4}$ m

$\therefore v = \frac{F}{6\pi r \eta} = \frac{6.91 \times 10^{-8} N}{6\pi \times 4.6 \times 10^{-4} m \times 1.41 \times 10^{-3} Pa s} = 5.65 \times 10^{-3} ms^{-1}$

Terminal velocity = 5.65×10^{-3} ms^{-1}

17(b)

This question was about how increasing viscosity affects terminal velocity. Many candidates did not realise that the drag force at terminal velocity remains the same, and that the velocity can decrease to provide sufficient drag if the viscosity becomes greater. Very few candidates mention any effect on the uprthrust of increasing density.

Discuss how the terminal velocities of forams change as they sink deeper into the sea.

(4)

weight, upthrust and drag force act on the forams.
Because the mass of forams is constant, f weight is constant.
Upthrust is related to density of sea water, as ~~wa~~ temperature of water becomes lower, sea ~~wat~~ water get ~~m~~ denser so the upthrust is bigger.
Drag force is related to viscosity of sea water, as temperature of water becomes lower, viscosity got bigger so drag force is bigger so the resultant force acting on forams is smaller, so the terminal velocities of forams is lower.

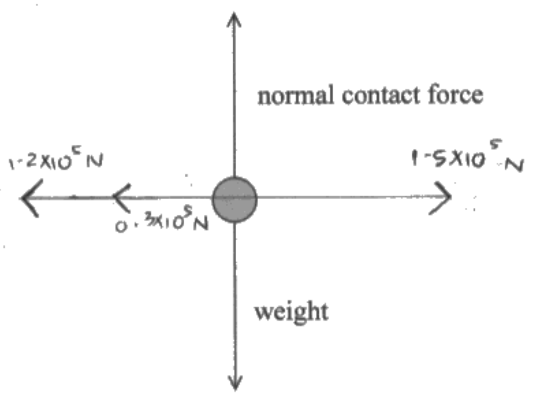
Question 18 The Shunting Engine

18(a)

An astonishing number of students were unable to answer this question correctly. The force pushing the engine forward is the reaction force from the rails due to the engine pushing the rails backwards, and the truck pushes the engine backwards if the engine pushes the truck forwards; these were a Newton third law situation. Many students failed to notice that an additional backwards force from air resistance was required to bring the engine into equilibrium.

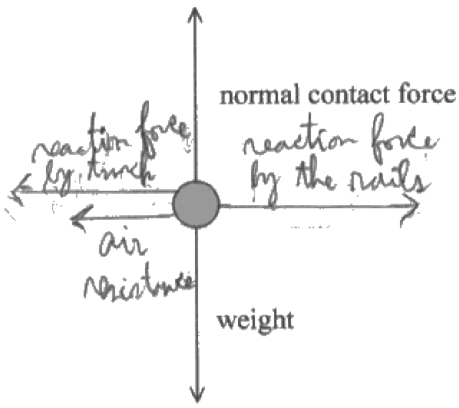
The arrows in a free-body force diagram should have lengths proportional to the magnitudes of the forces. This was very rarely seen. The first example shown scored four marks, the second only three.

(a) Complete the free-body force diagram to show all the forces acting on the engine. **(4)**



$1 \cdot 5 \times 10^5 - 1 \cdot 2 \times 10^5 = 0 \cdot 3 \times 10^5$ N

(a) Complete the free-body force diagram to show all the forces acting on the engine. **(4)**



18(b)

This was another standard question, and candidates generally scored well, though not many were able to score all available marks. Details of why the forces are not of the same nature required an account of what the natures of the forces are. In a mark-rich question such as these students should be advised that additional details are going to be needed if full marks are going to be awarded.

Explain why the student's suggestion is **not** correct. Your answer should include reference to the features of a Newton's third law pair of forces.

(5)

Newton's third law forces need to be of the same type, equal magnitude, opposite directions and acting on different bodies.
Weight is a gravitational force while the normal reaction is a contact force, hence they are not of the same type. They are also acting on the same body.
Even though they are equal in magnitude, opposite in direction, ~~and acting on differen~~ as all of the conditions for Newton's third law are not met, they are not paired forces.

Question 19 The Cyclist on the Hill

19(a)

This was a very easy opening part for the final question, and most candidates scored well. A common mistake was to multiple the distance by a cosine or a sine of the angle, giving the wrong distance.

(a) Show that the work done by the cyclist is about 3×10^4 J.

(2)

Work done = force × distance.

= 150 N × 215 m

= 3.2×10^4 J ≈ 3×10^4 J

19(b)(i)

Application of energy conservation was neede in order to account for the missing energy, the work done against air resistance. Some candidates calculated the change in g.p.e. and left that as a final answer.

(i) Calculate the work done by the cyclist against air resistance.

mass of cyclist and bicycle = 90 kg

(4)

F = 90g sin(4)

∴ W = 90g sin(4) × 215 = 1.3×10^4 J

work done ~~by~~ against gravity = 1.3×10^4 J

∴ Work ~~by~~ against air resistance = $3.2 \times 10^4 - 1.3 \times 10^4$

= 1.9×10^4 J

Work done against air resistance = 1.9×10^4 J

19(b)(ii)

This question was not well answered. Many students decided that there should be no friction between the cyclist and the road, not realising that that would mean the road was too slippery for the cyclist to make any progress whatsoever.

(ii) State one assumption that must be made when calculating the work done against air resistance.

(1)

No energy is dissipated inside the system — all the work done by the cyclist is transfered to GPE gained and work done against air resistance.

19(c)

This final question required the candidate to give a good reason for the cyclist's increase in speed, though clearly nearly all knew that it would be a greater speed. Most candidates had great difficulty accounting for this, many thinking that the force of gravity had a horizontal component, others getting confused between force, work and power.

Explain how the speed of the cyclist changes as the road becomes horizontal.

(2)

on horizontal plane, the cyclist doesnt have to do work againt the component of his weight. So for the same forward force, his velocity is going to be greater.

(Total for Question 19 = 9 marks)

Concluding Remarks

- Many students showed high levels of skill and knowledge of physics in this paper, and it was very pleasing to see some of the excellent examples of the efficient solutions some students presented, especially in the projectile question **Q15** and the Stokes' law question **Q16.**
- More time spent in reading the details of questions would greatly improve performance, particularly in the Newton third law question **Q18** and the energy conservation and work question **Q19**.
- Practice in graph work would also have been of great benefit for the Young modulus question **Q12(b)**.
- 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.
- Ambiguous statements do not score marks as an examiner cannot be expected to guess which meaning a student intended, this was particularly true of **Q14(b), Q16(c), Q17(b) and 19(c).**
- The recommendations for improving student performance remain similar to those in previous series, namely:

  - 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 that they do in fact understand.
  - Encouraging students to use calculators correctly, to round answers to three significant figures in the last line only but to carry all significant figures forward from line to line in their calculations. Judicious use of calculator memory can avoid rounding errors.
  - Reminding students that rather than leaving entire questions blank they can score marks with some simple statements without necessarily knowing how to finish a question.

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