Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

January 2022

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

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

January 2022
Publications Code WPH11_01_2201_ER

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 momentum question **Q11** and the pinball question **Q16** 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 the projectiles question **Q18(b)** and the Archimedes principle question on flotation **Q15**.

Explanations of physical phenomena were less well attempted; this was particularly evident in the decelerating lift and balance question **Q14** where students did not clearly show to which part of the narrative their explanations referred and often became confused as to what exactly it was, they were trying to explain. In **Q12(a)**, **Q15(a)**, **Q17(c)** and **18(c)** students often failed to address the main physical process at play. Students should be encouraged not to rush into answering questions without first reading them thoroughly.

A recurring theme in questions where a conclusion needed to be drawn or explained was students not showing a comparison of a calculated result with the condition that it needed to satisfy. This applied to **Q15(b)(ii)** and **Q18(b)**.

Final answers must be correctly rounded, not truncated, and truncated 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 nearly all papers.

SECTION A

Multi-Choice Items

	Subject	Correct response	Comment
1	Displacement *vs.* Time	**A**	Velocity is rate of change of displacement.
2	Vectors and Scalars	**D**	$F = m\,a$, multiplying a vector by a scalar gives another vector.
3	Velocity *vs.* Time	**A**	Constant negative gradient for negative velocity.
4	Vectors	**C**	Resulant of two coplanar vectors by calculation.
5	Equations of Motion	**C**	Application of $s = ut + \frac{1}{2}\,a\,t^2$ with $u = 0$.
6	Stokes' law	**B**	Increased viscosity gives lower terminal velocity for given mass and radius.
7	Newton's 3rd Law	**B**	Force of person on trolley and force of trolley on person are a Newton 3rd Law pair.
8	Stress	**A**	Doubling the diameter gives four times the cross section so four times the tension for the same breaking stress.
9	Moments	**C**	Moments of centre of beam are equal, *P* is further from the centre than *Q*, so less force than *P* is needed for the same moment.
10	Units	**B**	kg m s^{-2} are equivalent to N (force), N s are equivalent to kg m s^{-1} (momentum).

Multi-choice items were generally well-answered, students who scored well in Section A generally went on to score a good mark overall.

SECTION B

Exemplar items show examples of answers which scored full marks.

Question 11(a)The Colliding Asteroids

Most students knew that momentum is conserved, but many did not specify that it is the total momentum of a *system* that is conserved, which needed to be stated. The second mark was for stating the condition of zero external force, an essential detail that should be emphasised.

(a) State the principle of conservation of linear momentum.

(2)

total momentum before collision
equals total momentum after
collision in a closed system

Question 11(b)(i)

This was a simple application of $p = mv$ to find v. Most candidates were able to do this well, though a few truncated their final answer instead of correct rounding, or gave too few d.p.

(i) Show that the mass of asteroid A was about 8.2×10^{13} kg.

(2)

momentum = mass x velocity

1.8×10^{17} = mass x 2.19×10^{3}

mass = $\frac{1.8 \times 10^{17}}{2.19 \times 10^{3}}$ mass = 8.22×10^{13}

mass = 8.2×10^{13} Kg

Question 11(b)(ii)

The final part of the question was to apply the principle using the result of part (b)(i) to find the final velocity of the combined asteroids. This was generally well attempted, with the most common error being not adding together the two asteroid masses to find the combined mass. Some candidates wasted time re-calculating the momentum of asteroid A, which was given in the question.

(3)

$m_A \times V_A + m_B \times V_B = m \times V$

~~8.22×10^{13} Kg $\times$ 2.19×10^{3} ms^{-1} + 5.90×10^{12} kg x~~

8.22×10^{13} Kg $\times$ 2.19×10^{3} ms^{-1} + 5.90×10^{12} Kg $\times$ 15.0×10^{3} ms^{-1} = 8.81×10^{13} Kg $\times$ V

$\frac{2.69 \times 10^{17}}{8.81 \times 10^{13}}$ = V

3.053×10^{3} ms^{-1} = V

Velocity of asteroids = 3.053×10^{3} ms^{-1}

Question 12(a) The Counterweight

The question tested the students' ability to work out how having a counterweight benefits a lift system. This was not answered well overall; although most students concluded that a counterweight reduces the amount of work required, few were able to give a coherent explanation either in terms of energy or of forces. Many students talked about the counterweight balancing the lift, and very few talked about the forces on the lift motor.

(a) Explain how the counterweight affects the amount of work required from the electric motor to raise the lift.

(2)

The counter weight reduces the force required for the electric motor to pull
Work = Force x displacement, so the less force the less work. Because the counter weight and electric motor have torque so less force on the electric motor

Question 12(b)

This allowed students to demonstrate understanding of work and power, with most using the gain in GPE divided by the time taken to reach the correct answer. Common errors were in forgetting the factor of *g*, neglecting the weight of the counterweight, or adding it to the weight of the lift rather than subtracting.

Show that the output power of the electric motor is about 12 kW.

total mass of lift and people = 2250 kg
mass of counterweight = 1300 kg

W $P = \frac{mgs}{t}$

(4)

$P = \frac{Fs}{t}$

$= \frac{~~950 \times 9{\cdot}81~~\ 9319{\cdot}5 \times 40}{30}$

$= 12\,426\ W$

$F = W - T$

$= (2250 \times 9{\cdot}81) - (1300 \times 9{\cdot}81)$

$= 9319{\cdot}5\ N$

Show that the output power of the electric motor is about 12 kW.

total mass of lift and people = 2250 kg
mass of counterweight = 1300 kg

W $P = \frac{mgs}{t}$

(4)

$P = \frac{Fs}{t}$

$= \frac{~~950 \times 9{\cdot}81~~\ 9319{\cdot}5 \times 40}{30}$

$= 12\,426\ W$

$F = W - T$

$= (2250 \times 9{\cdot}81) - (1300 \times 9{\cdot}81)$

$= 9319{\cdot}5\ N$

Question 12(c)

This question was not well answered, many candidates did not know what to do with the dissipated energy and failed to add it to the input required to calculate the efficiency. A number subtracted it from the output power and others thought it was the output power. More care in energy accountancy is needed here.

(c) The electric motor dissipates energy to the surroundings at a rate of 3 600 W.

Determine the efficiency of the electric motor.

(2)

input = output + lost

ie = 12400 W + 3600 = 16000 W

efficiency = $\frac{output}{input}$,

eff = $\frac{12400}{16000}$ = 0.775, 78%

Efficiency = 78%

Question 13(a) The Tyrolean Traverse

Students were mostly able to resolve forces correctly for these rather simple statics problem, though a significant number omitted the factor of 2.

Show that the tension T in the rope is about 1.3×10^3 N.

(3)

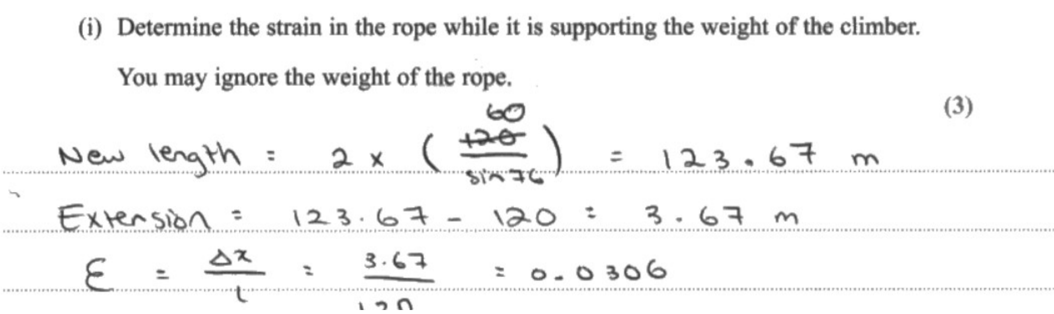
$2(T\cos 76°) = 650$

$T\cos 76° = 325$

$T = 1.34 \times 10^3$ N

Question 13(b)(i)

This question posed few problems for most students, with the most popular method being to find the stretched length of half the rope, doubly it and subtract the length of the unstretched rope. This problem can be solved without knowing the length of rope, but few students realised that. Problems in the application of trigonometry were mostly the cause of any confusion. A small number of students gave the strain in metres, which triggered a unit penalty as strain has no units.


(i) Determine the strain in the rope while it is supporting the weight of the climber.

You may ignore the weight of the rope.

(3)

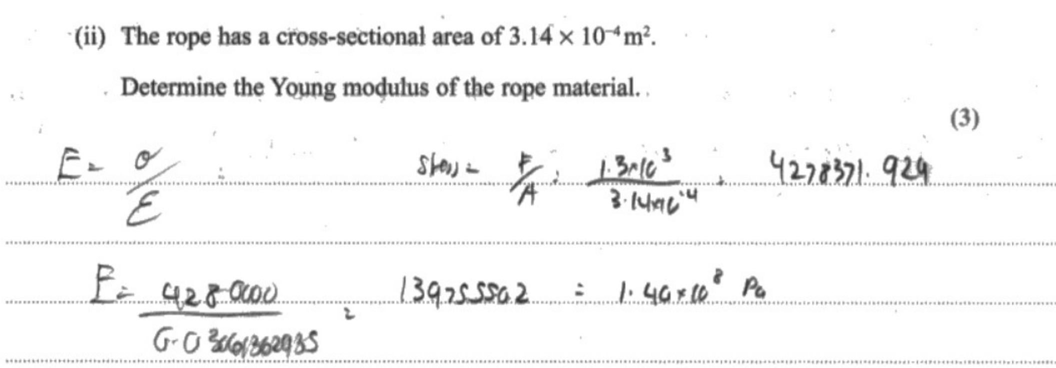
New length $= 2 \times \left(\frac{60}{\sin 76}\right) = 123.67$ m

Extension $= 123.67 - 120 = 3.67$ m

$\varepsilon = \frac{\Delta x}{l} = \frac{3.67}{120} = 0.0306$

Question 13(b)(ii)

For some reason, a very large number of students used a tension of 650 N for this calculation, even when they had correctly calculated the tension in part (a).


(ii) The rope has a cross-sectional area of 3.14×10^{-4} m^2.

Determine the Young modulus of the rope material.

(3)

$E = \frac{\sigma}{\varepsilon}$ stress $= \frac{F}{A} = \frac{1.3\times10^3}{3.14\times10^{-4}} = 4278371.929$

$E = \frac{4280000}{0.0306136203835} = 139755502 = 1.40\times10^8$ Pa

Question 14 The Decelerating Lift and the Scales (Linkage Question)

There were some very good responses to this question, but a great many students remain very unclear as to how resultant forces affect vertical motion. The question was about the reaction force between the floor of the lift and the student, as measured by the scales, as the lift decelerates from an initially upwards constant speed. Very few students explicitly stated this fundamental fact, which was IC1 and the key to the whole question. An explanation of why the scales registered the normal weight of the student before deceleration was needed for IC2 and IC3. Many students were under the impression that the upward force on the student needed to be greater than the weight of the student for constant upward motion, leading to some very confused and incoherent writing. Some students even told us that the reading on the scales decreases because the force of gravity becomes weaker as the lift goes higher.

The deceleration phase also caused problems, mostly with students failing to make it clear that the forces were on the student, not the lift. Explanations in terms of the tension in the lift cable scored no marks, though many were able to recover a mark from IC3 by stating that the reading on the scales returns to 600 N once the lift has come to rest.

On a more general point, students were often imprecise in use of language, for example to talk about the student "weighing less" is not physically correct, nor does it allow an examiner to award a mark for describing the scale reading. Students also tended to talk about how forces were acting without indicating which stage of the motion they were describing. Ambiguities such as these make it impossible to award marks, which is a shame if the student does understand what is going on.

Explain the readings on the scales.

When the lift moves up with constant velocity the acceleration is $0\,ms^{-2}$ hence the resultant force is also 0N which means his weight (downward force) = Normal reaction of scale on him (upward force) [assuming no drag]. This means that the scale reads 600N as it is equal to weight which is a constant 600N. When it decelerates it has negative acceleration hence negative resultant force (N2). (Resultant downwards). Since weight is constant, for ther to be a downward resultant the normal reaction needs to decrease hence Weight > Normal reaction and the reading on the scale is less than 600N.

(Total for Question 14 = 6 marks)

The scale reads the normal reaction.

Question 15(a) The Floating and Sinking Cylinders

The reason anything floats is because the upthrust of the fluid is equal to its weight, not greater. A disappointing number of students put the latter. A statement of Archimedes' principle provides the explanation for why the upthrust is sufficient. Explanations in terms of density are more difficult to justify, but many students were able to score marks with a slightly less direct explanation.

(a) Explain why the brass cylinder floats. **(2)**

As the weight of water displaced by the brass cylinder is equal to the weight of the brass cylinter, so weight = upthrust, hence floats.

Question 15(b)(i)

The mass of the cylinder is equal to the mass of the water it displaces. Students needed to calculate 63% of the volume of the cylinder and then use the density of water to get the mass. This question was generally well answered, but despite the mathematics to calculate the volume of a cylinder being a requirement of the specification many students were unable to apply the right formula. Students should be reminded to round values correctly, as incorrect rounding often lost the final mark.

(i) Show that the mass of the cylinder is about 9×10^{-3} kg.

(4)

$21 \div 2 = 1.05\ cm = 0.0105\ m$

$0.0105^2 \times \pi \times 0.04 = 1.385 \times 10^{-5}\ m^3$

$1.385 \times 10^{-5} \times 0.63 \times 1 \times 10^3 = 8.726 \times 10^{-3}\ kg$

Question 15(b)(ii)

There were a great variety of ways to solve this problem, and it was interesting to see some clever approaches by many students which had not been anticipated by the mark scheme. The most common error was to assume that the gold cylinder was solid, not hollow like the brass one, rendering spurious any conclusion about flotation. The simplest method was to compare the mass of the gold to the greatest mass of water that could be displaced.

(ii) Deduce whether an identical hollow cylinder made of gold would also float. Assume that the volume of gold is the same as the volume of brass.

density of gold = $19.3 \times 10^3\,\text{kg}\,\text{m}^{-3}$
density of brass = $8.7 \times 10^3\,\text{kg}\,\text{m}^{-3}$

(4)

$m_{gold} = V \cdot \rho = \frac{8.73 \times 10^{-3}\,\text{kg}}{8.7 \times 10^3\,\text{kg}\,\text{m}^{-3}} \times 19.3 \times 10^3\,\text{kg}\,\text{m}^{-3} = 1.9 \times 10^{-2}\,\text{kg}$ Weight $= mg = 1.9 \times 10^{-2}\,\text{kg} \times 9.81\,\text{N}\,\text{kg}^{-1} = 0.190\,\text{N}$

max upthrust $= \rho V g = 4\,\text{cm} \times \left(\frac{2.1}{2}\right)^2 \text{cm}^2 \times \pi \times 1\,\text{g}\,\text{cm}^{-3} \times g = 13.85\,\text{g} \times 9.8\,\text{N}\,\text{kg}^{-1} \times 10^{-3}$

$= 0.136\,\text{N}$

$0.136\,\text{N} < 0.190\,\text{N}$

∴ gold can't float

Question 16(a) The Pinball Machine

This was a simple use of the kinetic energy formula that caused students few problems apart from the occasional calculator error in squaring the velocity.

(a) Show that the kinetic energy of the ball just after launching is about 4×10^{-5} J.

mass of ball = 12 g

(2)

$E_k = \frac{1}{2}mv^2$ $m = 0.012$ kg, $V = 0.08$ m/s

$= \frac{1}{2} \times 0.012 \times (0.08)^2 = 3.84 \times 10^{-5}$ J

$\simeq 4 \times 10^{-5}$ J

Question 16(b)

This was also a simple application of the spring energy formula equated to the final k.e. of the pinball. This was well answered overall, though many students omitted the factor of ½, thus failing to score either mark. Students attempting to use Newton's second law failed to realise that the acceleration is not constant as the spring is released.

(b) Determine the force on the ball when the spring is released.

(2)

~~F = kx~~

$E = \frac{1}{2}Fe$ ~~4x10^-5 J~~ ~~4.80x10^-4 = ½ x F x 5~~

1m — 100cm $0.0000384 = \frac{1}{2} \times F \times 0.05$

x — 5cm $F = 0.0000384 / 0.025 = 0.001536$

Force = 1.54×10^{-3} N

Question 16(c)

This question gave few difficulties, being a straightforward application of Hooke's Law.

(c) Determine the stiffness of the spring.

(2)

$F = K \Delta x$ $\quad K = \frac{F}{\Delta x}$

$K = \frac{1.54 \times 10^{-3}}{0.05} = 3.07 \times 10^{-2}$

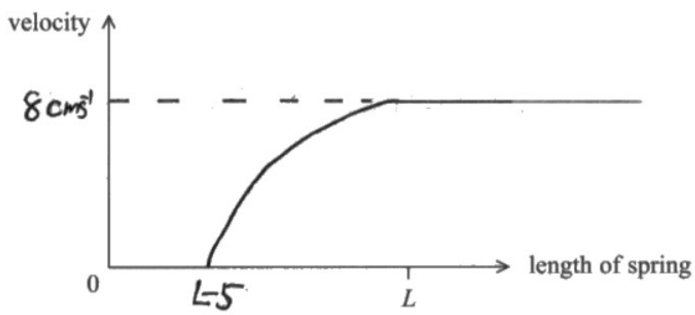
Stiffness = 3.07×10^{-2} N/m

Question 16(d)

A very difficult question for all candidates, only a small number identified that the gradient would decrease as the spring extended. Even then only a tiny minority thought 5to include the given launch velocity or even better the compressed length along the *x* axis of *L* − 5. Most drawn graphs just gave a straight line through the origin, almost the default setting for sketch graphs.

Sketch a graph, on the axes below, to show how the velocity of the ball varies with the length of the spring.

(4)



Question 17(a) The Viscous Fluid and the Sphere

The conditions for Stokes' law should be learned by candidates, and even though a sphere had been stated in the question, many candidates failed to specify that that was in fact one of the conditions. The most common mark scored was for laminar flow.

(a) Stokes' law can be used to calculate the drag force on an object.

State the conditions that must apply for Stokes' law to be valid.

(2)

Object must be spherical.

Liquid should be a laminar flow.

Question 17(b)(i)

Many students did not attempt this question, though it was a straightforward substitution and re-arrangement
for a terminal velocity. A common mistake was to use the wrong value for force, despite the force having been given in the question.

(i) At one instant, the speed of the sphere is $5.2 \times 10^{-3}\,\mathrm{m\,s^{-1}}$.

Calculate the resultant horizontal force on the sphere.

(3)

$F = 6\pi r \eta v$

$F = 6\pi \left(\frac{4.5\times10^{-3}}{2}\right) \times (7.1\times10^{-2}) \times 5.2\times10^{-3}$

$= ~~1.56~~\ 1.57\times10^{-5}$

$\therefore$ Resultant force $= 2.3\times10^{-5} - 1.57\times10^{-5}$

$= 7.3\times10^{-6}\,\mathrm{N}$

Question 17(c)

Both changes to the experiment result separately in a lower terminal velocity but many candidates did not clearly link that to a combined effect to score all marks. Most students stated that the viscosity increases with lowered temperature, though some had that the wrong way round, or stated that it would increase terminal velocity. The better answers talked in terms of drag force being greater at lower velocity.

• diameter is larger, so radius is larger, so v is lower as others are constant for set conditions

• lower temp means higher viscosity so also lower v as η is larger

• the maximum speed is much lower than before.

Question 18(a) The Stunt Motorcylist

The vertical and horizontal components of the motorcyclist's velocity were required, which caused few students any difficulty. The occasional student got the values the wrong way round, and some had calculators in "radian" mode, so did not score the second mark.

(a) Calculate the horizontal and vertical components of the motorcycle's initial velocity as it leaves the ramp.

(2)

horizontal = 35cos25 = 31.7m/s

vertical = 35sin25 = 14.8m/s

Horizontal component = 31.7m/s

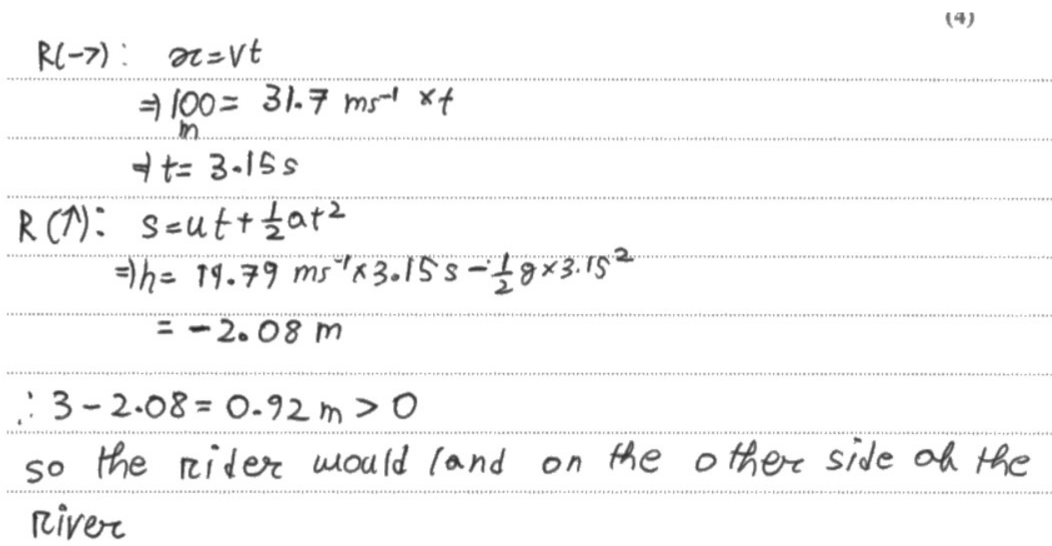
Vertical component = 14.8m/s

Question 18(b)

The simplest way to tackle this question was to find how long it took to cover 100 m horizontally and then to see whether the motorcyclist had a net drop of more than 3.00 m in that time. Those who adopted this approach reached the correct conclusion easily and scored all marks, though some failed to score the final mark by not giving a comparison of the two values.

A significant number of students calculated the time to drop 3.00 m (by various methods) and compared that either with the time to travel 100 m or used it to calculate the horizontal distance covered in that time, which also gives a clear result.

Those students who calculated the time to greatest height and then doubled it did not calculate the correct time as they needed to add the time taken to fall the last 3.00 m. This was a very common error, and students should be encouraged to draw clear sketches if they are to avoid this type of mistake.


(4)

R(→): $x = vt$

$\Rightarrow 100\,\text{m} = 31.7\ \text{ms}^{-1} \times t$

$\Rightarrow t = 3.15\,\text{s}$

R(↑): $s = ut + \frac{1}{2}at^2$

$\Rightarrow h = 19.79\ \text{ms}^{-1} \times 3.15\,\text{s} - \frac{1}{2}g \times 3.15^2$

$= -2.08\ \text{m}$

$\therefore 3 - 2.08 = 0.92\,\text{m} > 0$

so the rider would land on the other side of the River

Question 18(c)

This final question on how a consideration of air resistance might affect the trajectory of the stunt motorcyclist suffered from lack of precision by students. It is important in projectile motion to distinguish between the horizontal and vertical components of the motion and though many students seemed to have a basically correct idea, crucial details were often missing form their explanations, details such as the directions of the forces and whether the distance covered was a displacement, and in what direction. There were many very good answers, but students who clearly had a good feel for the effect sold themselves short with imprecise language.

Air resistance would act against the ~~thu~~ motorcyclist's motion, slowing down it's motion. Therefore, it ~~would~~ the velocities of the motorcycle would decrease (it would experience deceleration), resulting in ~~a~~ lower vertical and horizontal displacements, so it's maximum height would be lower and it's horizontal displacement too. The time taken to land would be greater.

(Total for Question 18 = 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 and Archimedes' principle questions.

More time spent in reading the details of questions would greatly improve performance, particularly in the extended open response question and in the Archimedes' principle question. Practice in rearranging and combining formulae would also be of great benefit, in this paper particularly in the power question and the Alpine traverse question.

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.

The recommendations for improving student performance remain like 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 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.

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom