Pearson Edexcel

Examiners' Report

Principal Examiner Feedback

October 2020

Pearson Edexcel International Advanced Subsidiary Level

In Physics (WPH11)

Paper 01 Mechanics and Materials

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General Introduction

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 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 **Q13(b)**, **Q17(a)(iii)**, and **Q18(b)**. It was disappointing to see so few students attempting the last question **Q19(b)(iii)** where there were also several ways of approaching the scenario.

Explanations of physical phenomena were less well attempted, it was very common for students to miss key mark-bearing points, particular examples being **Q12(b)** where the directions of forces were often not given sufficient prominence, **Q16(c)** which was a very basic analysis of springs in series, and **Q19(a)(iii)** where students should have been able to relate the weight of the cable to the forces supporting it.

A recurring theme in questions where a conclusion needed to be drawn was students not scoring the final mark due to there being no comparison of a correctly calculated result with the condition that it needed to satisfy. This applied particularly to the projectile question **Q17(a)(iii)** and the moments question **Q13(b)**.

Familiarity with the core practicals is very important if students are to make sensible comments regarding questions on those practicals. The viscosity practical **Q15** seemed unfamiliar to some students, who seemed to think that the sphere is dropped from a height into the liquid, and many students also seemed unfamiliar with the procedure for taking a Young modulus from a stress-strain graph **Q16(a)(i)**.

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

Multiple Choice

	Subject	Correct response	Comment
1	Units and vectors	**C**	Force is a vector denominated in newtons.
2	Newton's Third Law	**B**	F is the frictional force of the ramp on the box and R is the reaction force of the ramp on the box.
3	Conservation of energy	**D**	The fall is $h = 45$ m and $v = \sqrt{(2gh)}$
4	Kinematics	**B**	The change in velocity is the final velocity minus the initial velocity.
5	Addition of vectors	**D**	The resultant is the sum of the vectors.
6	Efficiency	**D**	Input = Output ÷ Efficiency
7	Determination of g.	**B**	Velocity requires only two measurements.
8	Elastic energy	**C**	$F = \sigma A$ and $E_{el} = \frac{1}{2}F\Delta x$
9	$v - t$ graph	**B**	Area under graph gives displacement
10	$s - t$ graph	**C**	Integral of graph in Q9.

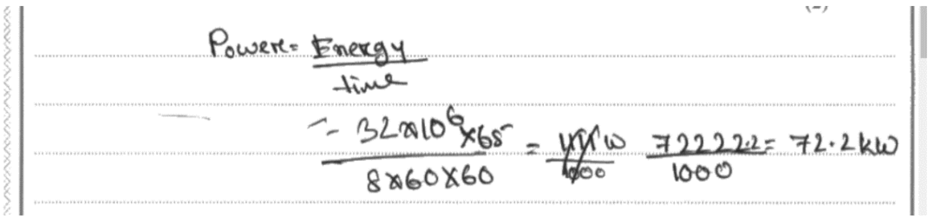
Written Responses

Examples show responses that scored full marks.

Question 11

This was a relatively straightforward question where students were expected to deploy some simple formulae to calculate an efficiency in part (c) using their answers to the first two parts. A large number of students were able to score full marks on all three sections. Mistakes included failing to multiply by the number of litres in part (a) and forgetting that the time in hours needs to be multiplied by 60 twice to get the time in seconds. Part (c) was generally correct as the students' values from the first two parts could be carried forward, and the "show that" values could also be used.

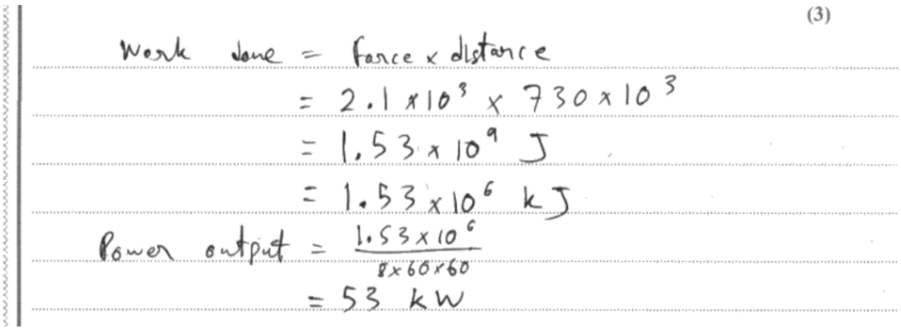
Question 11(a) - 2 marks



Power = $\frac{\text{Energy}}{\text{time}}$

$= \frac{32 \times 10^6 \times 65}{8 \times 60 \times 60} = \frac{722222.2}{1000} = 72.2\text{ kW}$

Question 11(b) - 3 marks



(3)

Work done = force × distance

$= 2.1 \times 10^3 \times 730 \times 10^3$

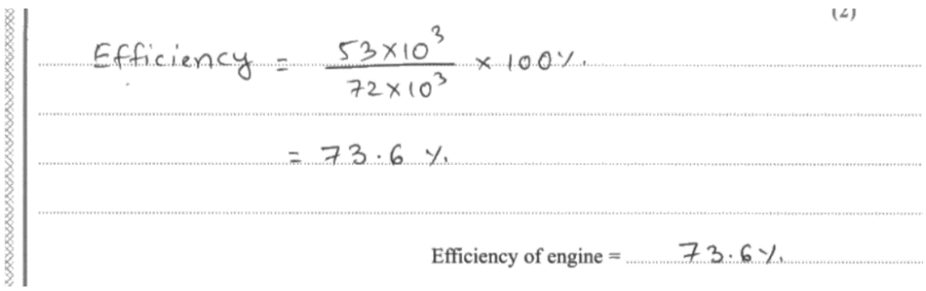
$= 1.53 \times 10^9$ J

$= 1.53 \times 10^6$ kJ

Power output = $\frac{1.53 \times 10^6}{8 \times 60 \times 60}$

= 53 kW

Question 11(c) - 2 marks



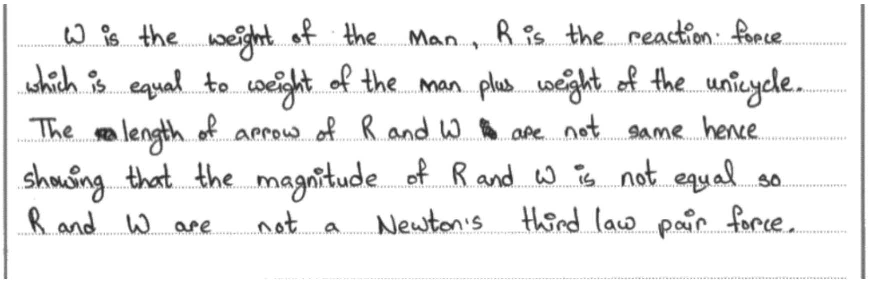
Efficiency = $\frac{53 \times 10^3}{72 \times 10^3} \times 100\%$

= 73.6 %

Efficiency of engine = 73.6 %

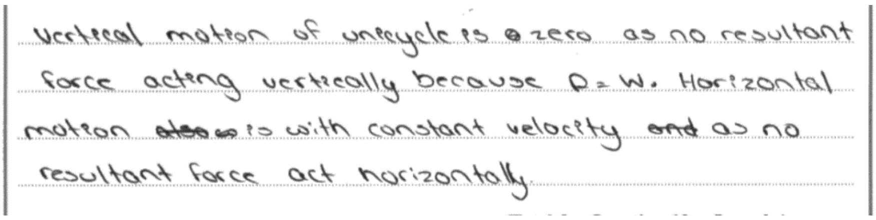
Question 12(a) - 3 marks

This question tested a student's understanding of Newton's Third Law and required the student to identify the forces *W* and *R* from the diagram. The question was not well answered on the whole. The identity of the forces was crucial for explaining the conclusion as *W* is the weight of the person (the gravitational force of the Earth on the person), and *R* is the reaction force of the Earth on the monocycle. The two arrows were also different lengths denoting different magnitudes. Most students did not identify the forces, although many used the difference on magnitudes to conclude that the forces are not a Newton Third Law pair.


W is the weight of the Man, R is the reaction force which is equal to weight of the man plus weight of the unicycle. The length of arrow of R and W are not same hence showing that the magnitude of R and W is not equal so R and W are not a Newton's third law pair force.

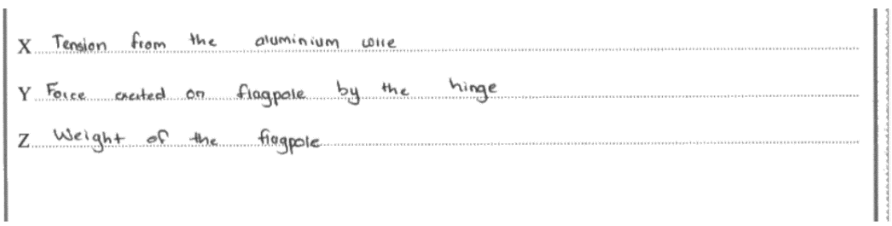
Question 12(b) - 2 marks

Student's needed to show that both the upward and downward forces add to zero net force, but also needed to explain that the consequence is no movement in the vertical direction. Students also needed to explain that the speed of the unicycle is constant because the horizontal resultant force is zero, the forward frictional force from the ground is balanced by backward drag forces. Many students did not discriminate between the horizontal and vertical directions, and so did not give an adequate explanation for the motion. Quite a few students seemed to think that the frictional force was a backward force and that the forward force was a force from the pedals.


Vertical motion of unicycle is zero as no resultant force acting vertically because R = W. Horizontal motion is with constant velocity as no resultant force act horizontally.

Question 13(a) - 3 marks

Students were asked to identify the forces shown on the free body diagram. There was quite a bit of sloppy work here, with a great many students simply giving the name of a force without stating what was exerting the force. It was very common for students to gain only one mark from this very easy question due to "weight" by itself being accepted for part (iii), since it is unarguable that only the Earth can exert that force.


X Tension from the aluminium wire

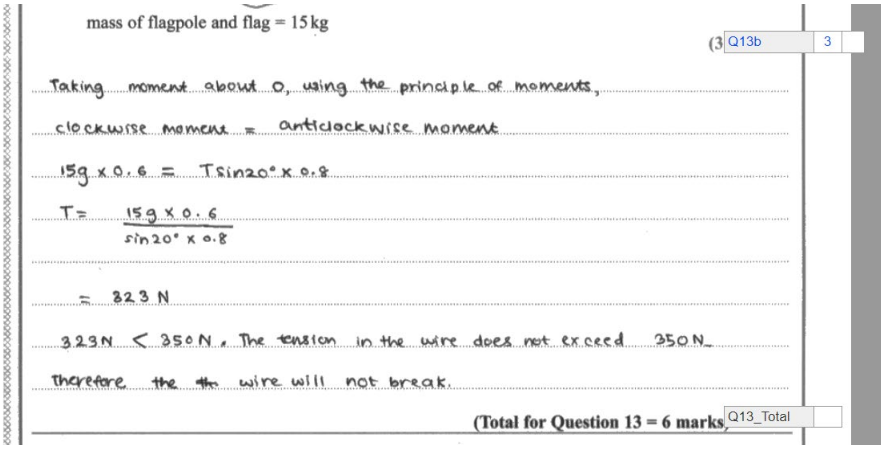
Y Force exerted on flagpole by the hinge

Z Weight of the flagpole

Question 13(b) - 3 marks

Many students were able to compute the tension in the wire by using the Principle of Moments, the final mark was often not scored due to the student not comparing the tension with the breaking tension. The most common method was to find the actual tension, though some students worked out the greatest turning moment that 350 N could sustain and showed that the actual moment from the weight of the flagpole was less than that.

Method 1


mass of flagpole and flag = 15 kg

(3) Q13b 3

Taking moment about O, using the principle of moments,

clockwise moment = anticlockwise moment

$15g \times 0.6 = T\sin 20° \times 0.8$

$T = \frac{15g \times 0.6}{\sin 20° \times 0.8}$

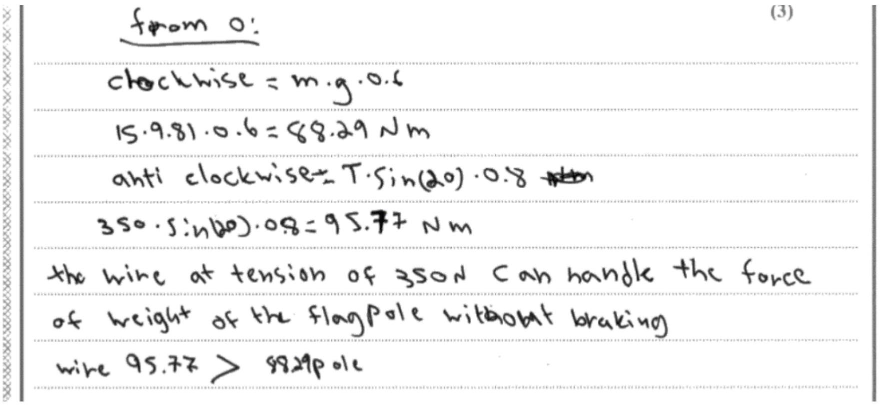
$= 323$ N

323N < 350N. The tension in the wire does not exceed 350N.

Therefore the ~~th~~ wire will not break.

(Total for Question 13 = 6 marks) Q13_Total

Method 2 (rare)


from O:

(3)

clockwise = m.g.0.6

15.9.81.0.6 = 88.29 Nm

anti clockwise = T.sin(20).0.8

350.sin(20).0.8 = 95.77 Nm

the wire at tension of 350N can handle the force of weight of the flagpole without braking

wire 95.77 > 88.29 pole

Question 14 - 6 marks

Students were asked to explain the shape of an acceleration graph for a skydiver. The graph is explained in terms of the resultant force on the skydiver and so various key events needed to be associated with different sections of the graph. The vast majority of students were able to describe how the resultant force changes due to increasing and then decreasing air resistance, but only a very few explained the initial acceleration and lower final terminal velocity. Many students confused drag with upthrust.

- Initially, drag force on skydiver is zero, hence acceleration is maximum.
- As ~~this spe~~ velocity increases, air resistance increases, resultant force downwards decreases and acceleration decreases.
- When, air resistance equal to weight, no resultant force on skydiver, therefore acceleration zero, reaches terminal velocity.
- At t_1, when opens parachute, the surface area increases hence air resistance increases greatly (D>W), resultant force upwards hence deceleration.
- As velocity decreases, air resistance ~~ata~~ also decreases and (W = D) hence terminal velocity reached is lower

Question 15(a)(i) - 2 marks

This was a question about a required practical where it is important that the terminal velocity of a sphere falling in a fluid is measured. It was common to see students focusing on the shortness of the distance rather than its being there so that terminal velocity can be established before timing begins. If the sphere is released just above the oil level then it will be accelerating, not decelerating, before the first rubber band is reached, and that needed to be stated to score full marks.

Because sphere ~~is~~ takes ~~times~~ time to reach the terminal velocity. At first when ball is dropped, the sphere accelerating but when it comes to the bottom the sphere has reached its maximum velocity or terminal velocity.

Question 15(a)(ii) - 2 marks

There were two acceptable answers to this question. The first, and better, is that dividing the distance into two equal part allows the times to be compared and thus to establish whether or not terminal velocity is achieved. The alternative answer was that by obtaining a repeat reading of the velocity an average could be taken. Many students did not score full marks due to careless writing, some simply giving vague generalisations such as "for greater accuracy" without explanation.

(2)

> The time ~~b~~ between first two rubberband and ~~second~~ time between ~~a~~ second ~~~~ and third band can be compared ~~and the~~.
> The Speeds can be compared to see whether terminal velocity has reached.

(2)

> Measure time taken to fall twice and calculate an average. More accurate results. Lower measurement uncertainty.

Question 15(b)(i) - 1 mark
Question 15(b)(ii) - 1 mark
Question 15(b)(iii) - 1 mark

Students are expected to know that drag is not always viscous, and that Stokes' Law is for viscous drag, so simple stating "drag" for part (iii) was not sufficient. Parts (i) and (ii) were generally answered well.

(i) Which quantity is represented by $\frac{4}{3}\pi r^3 \rho_s g$? **(1)**

> Weight of the sphere

(ii) Which quantity is represented by $\frac{4}{3}\pi r^3 \rho_o g$? **(1)**

> Upthrust acting on the sphere

(iii) Which quantity is represented by $6\pi r\eta v$? **(1)**

> ~~Drag force~~ Viscous drag

Question 15(b)(iv) - 1 mark

The main point of the question was for students to show that they understood viscosity to decrease with increasing temperature, and that was generally well done. Other experimental measurements could also be in error, for example the recorded time might have been shorter than the true time, or the recorded distance greater than the true distance. Such answers were seldom seen, though.

> A lower value of viscosity could be obtain, if the temperature was greater than 24°c

Question 16(a)(i) - 1 mark

A simple statement that K was the limit of proportionality was sufficient to score the mark. Students should be wary of saying too much, particularly if they then go on to contradict themselves by talking about elastic limits or plastic deformation. If describing the significance at was important to state that the point is a limit, and that proportionality ceases beyond it.

> (i) State the significance of point K.
> (1)
>
> K is the limit of proportionality, until K, the spring obeys Hooke's law, extension is proportional to force added till K.

Question 16(a)(ii) - 2 marks

The question gives that this point is the elastic limit, therefore a clear description is necessary to explain the significance. Many students suggested that this point was the yield point; the specification draws a distinction between yield point and elastic limit, thus "yield point" is not an acceptable answer.

> (ii) Explain the significance of point L.
> (2)
>
> after point L the material will show a ~~pl~~ plastic deformation and will not go back to its ~~starting~~ original length at the start of the experiment.

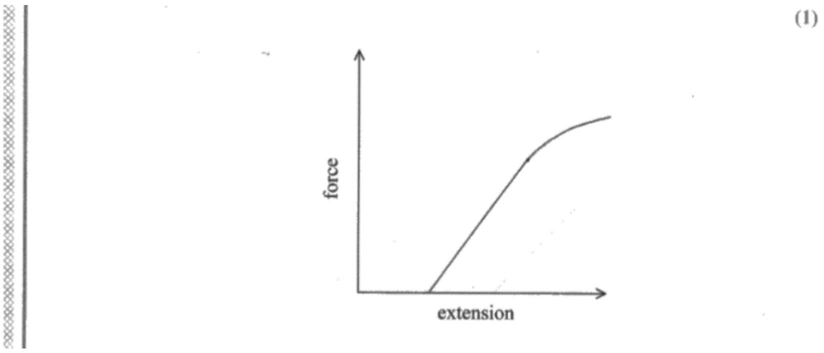
Question 16(a)(iii) – 1 mark

It was extremely rare to see a correct answer for this question, which is simply that the spring constant, or stiffness, has changed. The question was about the gradient, not the final length after unloading and very many students talked about the permanent deformation, not the gradient. This is an example of where students should read the question carefully.

> because it will have lower stiffness compared to loading the spring

Question 16(b) - 1 mark

This was mostly answered well. Forgetting to subtract the original length adds a constant length to all the reading on the *x*-axis so the whole graph shifts to the right. Many students did not score the mark because they shifted the graph up, not right; others failed to include an initial straight proportional section; still others only had a straight section and did not finish the line.



Question 16(c) - 4 marks

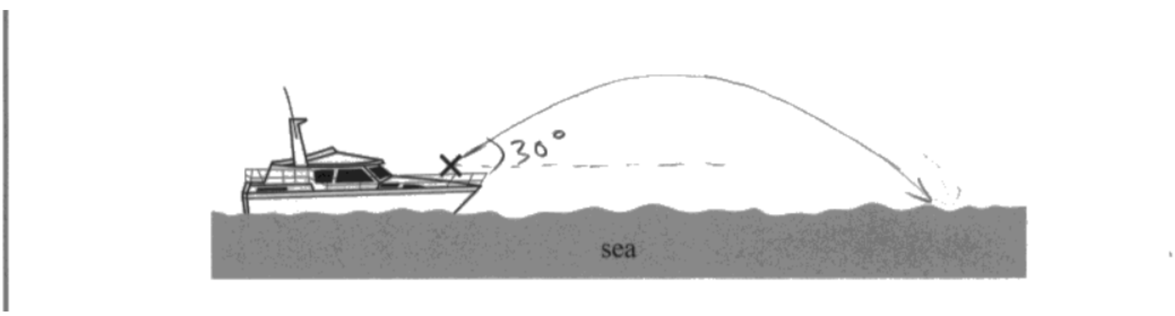
This question was surprisingly badly answered. Springs in series add their extensions and both are subjected to the full force of the weight, so the extension is doubled for the same force. Those students who seemed to understand this were often unable to explain it in an unambiguous way and so could not score all the marks. Many students seemed to think that the weight was shared and that this somehow halved the spring constant, and others simply tried to apply spring formulae without explaining where those came from. Clearer writing is needed for this type of question.

(4)

$F = K\Delta x$, if the springs are identical, then the same Force applied would cause the same extension, so if the same Force causes double the extension (total extension due to having two springs extend the original length) then K must be half for each spring, $F = k\Delta x$, $F = \frac{1}{2}K \times 2(\Delta x)$

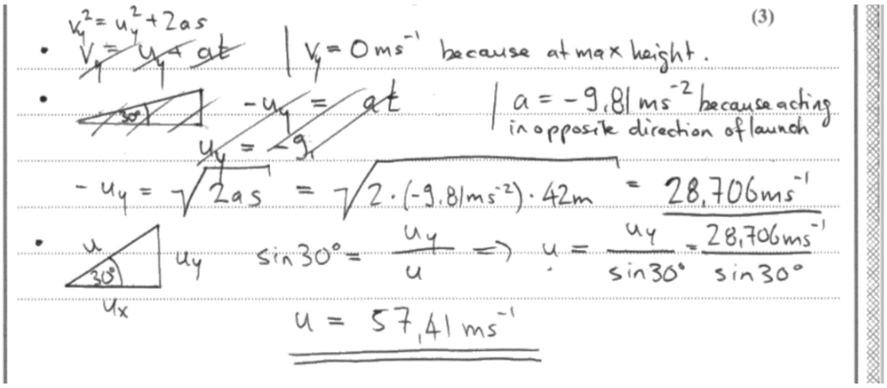
Question 17(a)(i) - 1 mark

Most students drew a decent sketch of the required parabola, though some seemed not to have a good feel for what 30° looks like. Those who did not score this mark often drew straight lines, or only half the parabola, or had angles well in excess of 45°.



Question 17(a)(ii) - 3 marks

This was a well answered question. Most students could obtain the vertical component from the correct SUVAT equation, though errors occurred in getting from there to the required answer.


(3)

$v_y^2 = u_y^2 + 2as$

• ~~$v_y = u_y + at$~~ | $v_y = 0\,ms^{-1}$ because at max height.

• ~~$-u_y = at$~~ ~~$u_y = -g$~~ | $a = -9.81\,ms^{-2}$ because acting in opposite direction of launch

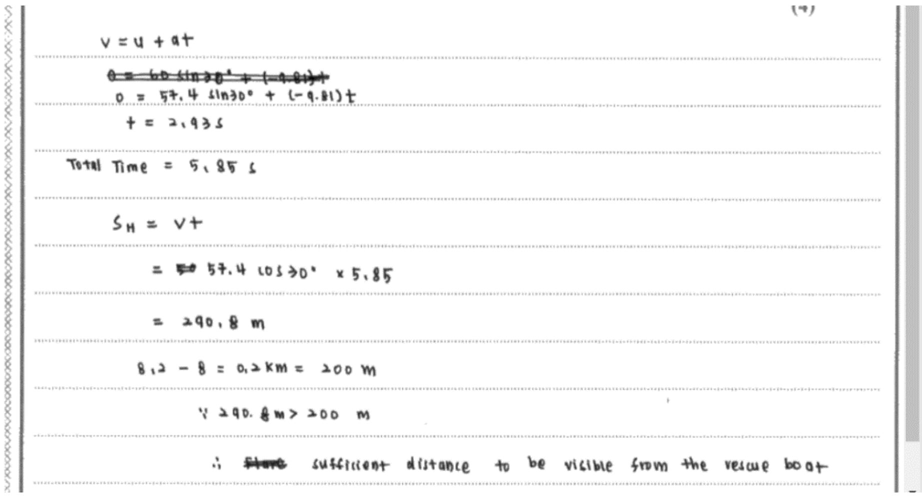
$-u_y = \sqrt{2as} = \sqrt{2\cdot(-9.81ms^{-2})\cdot 42m} = 28.706ms^{-1}$

• $\sin 30° = \frac{u_y}{u} \Rightarrow u = \frac{u_y}{\sin 30°} = \frac{28.706ms^{-1}}{\sin 30°}$

$u = 57.41\,ms^{-1}$

Question 17(a)(iii) - 4 marks

There were two principal ways to solve this problem with most students choosing to see how far the flare goes before hitting the sea and comparing that with the distance required to be seen. A second method (very rare) was to determine whether the flare is still airborne after travelling 200 m, in which case it would be visible from the rescue boat. The question was generally well answered with the exception of the comparison of distances, which was often vague or missing. Some students calculated the 291 m and added it to 8 km, but did not explain that they were considering (if they were) a hypothetical maximum distance from the boat to the rescue boat.


(4)

$v = u + at$

~~$0 = 60 \sin 30° + (-9.81)t$~~

$0 = 57.4 \sin 30° + (-9.81)t$

$t = 2.93\,s$

Total Time = 5.85 s

$S_H = vt$

$= 57.4 \cos 30° \times 5.85$

$= 290.8\,m$

$8.2 - 8 = 0.2\,km = 200\,m$

$\because 290.8\,m > 200\,m$

∴ ~~flare~~ sufficient distance to be visible from the rescue boat

Question 17(b) - 1 mark

Many students stated that they were assuming no air resistance, which is incorrect physics, there is always air resistance if there is air. We may neglect it if it is negligible, or ignore it if we do not have the relevant information needed to include it.

(b) State one assumption you made in (a)(iii). (1)

That air resistance is negligible.

(b) State one assumption you made in (a)(iii). (1)

air resistance was ignored
and launch angle 30°

Question 18(a) - 3 marks

This was generally well answered with many scoring full marks. Those who did not score full marks typically made errors by multiplying masses by the wrong velocities.

Momentum before = Momentum after.
⇒ 1·6 × 0·17 = (0·3 × 0·17) + (0·035 × v)
⇒ 0·035 × v = 0·221
⇒ v = 6·31 m/s.

v = 6·31 m/s

Question 18(b) - 6 marks

This question could be, and was, answered in one of two ways. The simplest was to find the difference between initial k.e. and final g.p.e. and divide it by the given distance along the ramp. A common error with that approach was to miscalculate the gain in height.

$L = 6.5cm = 6.5 \times 10^{-2} m \quad m = 0.035 kg$

$\sin 30° = \frac{h}{L} = \frac{h}{6.5 \times 10^{-2}} \quad h = 0.0325 m.$

$E_k = E_{grav} + fL$

$\frac{1}{2}mv^2 = mgh + fL.$

$\frac{1}{2} \times 0.035 \times 5^2 = 0.035 \times 9.81 \times 0.0325 + f \times 0.065$

$f = 6.56 N$

In the second method students used a SUVAT equation to find the deceleration and then used Newton's Second Law to find the resultant force. A separate calculation was required to determine the contribution made by the component of weight down the slope which would then be subtracted from the resultant force to find the remainder, the contribution made by friction. Students generally scored fewer marks with this method as there were more opportunities to make mistakes.

s = 0.065m u = 5 v = 0 a = a t =

$v^2 = u^2 + 2as$

$a = \frac{v^2 - u^2}{2s} = \frac{-5^2}{2 \times 0.065} = -192.3\ ms^{-2}$

resultant Force = $F_r = ma = -192.3m$

$W = mg = 9.8m$

$W_{parallel} = 9.8m \sin 30 = 4.9m$

~~Work done = Fas = 9.8m × 0.065 = 0.637m~~

~~0.637 Fas = ½mv², F =~~

~~Fr = Ff + W − Work done~~ $F_r = F_f + W$

~~Ff = −Work done + Fr + W = −166.5 + 192.3 + 9.8 = 35.6~~

$F_f = F_r - W = m(192.3 - 4.9) = 6.6$

Frictional force = ~~35.6N~~ 6.6N

Question 19(a)(i) - 1 mark

There were plenty of factors to choose from for this question. Students should remember to choose only one, there is no advantage in putting two, which runs the risk of losing the mark by suggesting a factor that is irrelevant. Most students chose the weight of the cable, or the distance between the pylons. Those who chose the number of birds sitting on the wires overestimated the weight of a bird.

(i) Suggest one further factor that may increase the sag of a cable. (1)

~~the humidity~~ Weight of the cable.

(1)

~~The~~ The ~~vertical distance~~ ~~has~~ closeness of both plylon

(1)

length of the cable

Question 19(a)(ii) - 3 marks

This was another question which was answered surprisingly badly on the whole. It is the vertical component of the tension in the cable which supports the weight of the cable and many students discussed the horizontal component. Although there are two support points many students did not include the factor of 2 in their explanations, so failed to score full marks. Stating obvious facts can also score marks, such as that the angle increases as the sag increases.

(ii) A cable of mass M is at an angle θ to the horizontal.

Explain why the tension in the cable decreases as the sag increases.

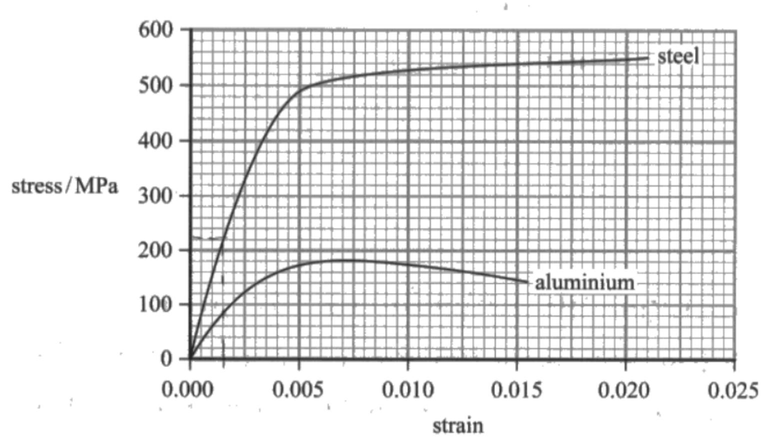
(3) Q19aii 3

$2T\sin\theta = Mg$

If vertical distance of sag increase, θ would increase. The value of sin θ would increase. Since Mg is constant, Tension in the cable would decrease.

Question 19(b)(i) - 2 marks

The Young modulus applies only to the proportional section of the graph, students could either use points within that section to calculate the gradient or could draw a tangent at the origin and find the gradient of the tangent using a longer line. Both methods gave a Young modulus within tolerance so those who used it generally scored both marks. A great many students used values outside the proportional region, and those values did not round to the required value.

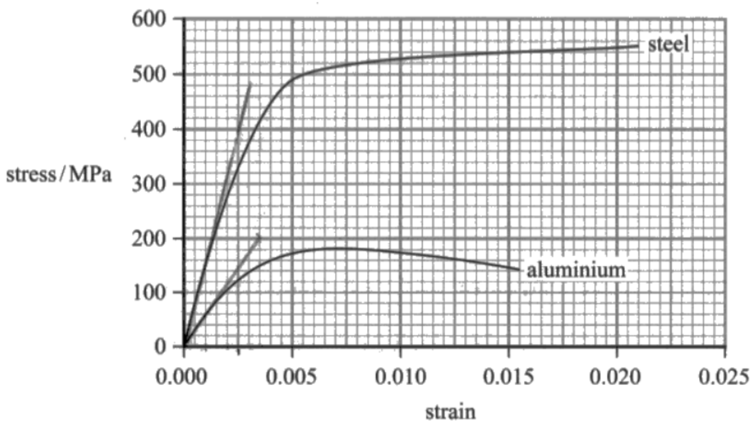


(i) Show that the Young modulus of steel is about 2×10^{11} Pa.

(2)

$E = \frac{220 \times 10^6}{0.0015} = 1.5 \times 10^{11}$ Pa

$\approx 2 \times 10^{11}$ Pa.



(i) Show that the Young modulus of steel is about 2×10^{11} Pa.

(2)

Young modulus = $\frac{\text{stress}}{\text{strain}}$ = gradient

$\frac{400 \times 10^6}{0.0025} = 1.6 \times 10^{11}$ Pa = ~~$\frac{40 \times 10^9}{16 \times}$~~ ~~$\frac{40 \times 10^9}{0.0025}$~~ = ~~F.~~

Question 19(b)(ii) - 2 marks

Most students were able to score both marks for this question, which was good to see near the end of the paper. The most common error was incorrect rounding.

tension per m for steel = 0.62 N m^{-1}

$\sigma = \frac{F}{A}$ $\quad F = 0.62 \times 270$

$= 167.4$ N

$\sigma = \frac{167.4}{2.3 \times 10^{-6}}$

$= 72.8 \times 10^6 = 72.8$ MPa as required.

Question 19(b)(iii) - 3 marks

There were two ways of answering this question. One method was to use the graph to obtain the strain in steel at 70 Mpa, or use the answer to (b)(ii) and divide it by the answer to (b)(i), and then find the extension for a length of 270 m. A minority of those that attempted this question used this method. Very few went on to compare the extension for steel with that given for aluminium and then go on to say that steel was used to reduce the sag.

As ~~the~~ steel has a higher young's modulus, the extension produced for one strand of steel would be →

$E = \frac{\sigma}{\varepsilon}$

$\varepsilon = \frac{72.9 \times 10^6}{1.6 \times 10^{11}}$

$\varepsilon =$ ~~3.64×10^{-04}~~

$= 4.6 \times 10^{-4}$

$\frac{\Delta x}{x} =$ ~~3.64 x~~ 4.6×10^{-4}

$\Delta x = 4.6 \times 10^{-4} \times 270$

$= 0.12$ m

↳ This value is lower than that of Aluminium (as steel is stiffer). So steel is used to ensure there is not as much sag or increase in length of wire for a ~~given~~ given ~~high~~ high stress value.

The other method was rarely seen. This involved finding the strain for an extension of 0.95 m and then using the graphs to find the stress in both aluminium and steel and comparing the two stresses so the stiffness of the cable increased to reduce the sag.

(3)

The strain of the aluminium strand $= \frac{0.95\text{m}}{270\text{m}}$

$= 0.0035$

At $\varepsilon = 0.0035$, the stress that could be withstood for the ~~aluminium~~ aluminium strand is around 150 MPa, whereas the stress that the steel strand can withstand is 410 MPa.

This shows that steel is much more stiffer than aluminium, and adding a steel core increases the stiffness of the cable, hence the sag would decrease and the cable would be kept at a considerable distance from the ground.

Conclusion

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 moments, momentum, and the projectile questions.

Greater familiarity with the core experiments would be beneficial to students as these contexts will occur frequently in examinations. Practice in obtaining gradients of graphs, and in justifying experimental procedures would give students more confidence in giving correct answers, and less pressure simply to state something vague about improving accuracy.

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 similar to those in previous series, namely:

- Time spent in performing, as well as describing and writing up, core practicals 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.

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