AQA A-LEVEL PHYSICS · 7408

PHYSICS



MARK SCHEME

3.4.2 MATERIALS

SCORE	PERCENTAGE
/73	%

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Q1.

(a) resultant/overall/sum of force = 0 OR forces up equal forces down AND forces left equal forces right ✓
(sum of) anticlockwise moments (about any point) = (sum of) clockwise moments/zero resultant moment/torque ✓

1
1

(b) EITHER
the point through which (the line of action of) a force has no turning effect/causes no rotation/ no torque ✓
OR
where the mass of the body can be considered to be concentrated OR where the weight can be considered to act ✓

NOT where mass can be considered to act
Ignore reference to force of gravity

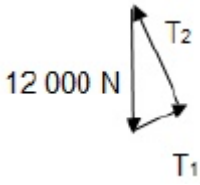
1

(c) so there is not a resultant moment/turning effect / turning force OR moments do not balance OR (beam) does not rotate / oscillate / swing ✓
about A / because A is pivot ✓

Allow moments balanced for no resultant moment

1
1

(d)



$T_1 = 12\,000 \cos 53$ ✓
$T_1 = 7200\ (7221)$ (N) ✓
$T_2 = 12\,000 \sin 53$ ✓
$T_2 = 9600\ (9583)$ (N) ✓

OR

$T_1 \cos 53 + T_2 \cos 37 = 12\,000$ ✓
$T_1 \sin 53 = T_2 \sin 37$ ✓
$T_2 = T_1 \sin 53 / \sin 37$
hence
$T_1 \cos 53 + T_1 \sin 53 \cos 37 / \sin 37 = 12\,000$
$T_1 = 7200\ (7221)$ (N) ✓
$T_2 = 7221 \sin 53 / \sin 37 = 9600\ (9583)$ (N) ✓

If T_1 and T_2 are the wrong way round get 3 out of 4
If scale drawing 2 max +/- 300(N)
If values out by a factor of 10 then -1 (i.e. confusion over g)

1
1
1
1

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(e) (use of $\Delta l = Fl/AE$)

A = $\pi \times (0.75 \times 10^{-2})^2$ ✓ (= 1.767×10^{-4})

$\Delta l = 12\,000 \times 12/(1.767 \times 10^{-4} \times 200 \times 10^9)$ ✓

$\Delta l = 4.1 \times 10^{-3}$ (m) ✓

No attempt to calculate area scores zero

Wrong area (e.g. d^2 or $2\pi r$ or $2\pi rl$) maximum 1 mark unless diameter used for radius in πr^2 then maximum 2 marks

Accept 4.0×10^{-3}

If 4×10^{-3} then -1 as 1 sig. fig.

1
1
1

[12]

Q2.

(a) Use of $n_A = \frac{c}{c_A}$ to make c_A the subject of the equation

Condone truncation without appropriate rounding mid-calculation

OR

speed in glass **A** = 2.05(2) × 10^8 ms^{-1} 1✓

Speed in glass **B** = 1.985(3) × 10^8

Condone use of $c = 3 \times 10^8$

But must see answer to 4 sf answer

OR

their speed in glass **A** × 0.96748 (or equivalent) 2✓

Values obtained using $c = 3 \times 10^8$:

- *speed in glass A = 2.05(3)× 10^8 ms^{-1}*
- *speed in glass B = 1.98(7) × 10^8*
- *n = 1.510*

OR

Alternative 1st and 2nd marks

Use of $n_A/n_B = c_B/c_A$ by substitution for n_A 1✓

Use of $n_A/n_B = c_B/c_A$ by substitution for n_A and $c_B = c_A \times 0.96748$ 2✓

OR

n_B = 1.461 / 0.96748 1✓2✓

Watch for maths errors:

Dividing by 1.03252 ≠ multiplying by 0.96748

Multiplying by 1.03252 ≠ dividing by 0.96748

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1.510 cao to 4 sf only $_3$✓

Correct answer to 4 sf obtains all 3 marks

Penalise any unit on final answer

3

(b) **Relationship:**

Increase in tension (or stress) in cable produces increase in strain resulting in increase in λ_R

OR

Decrease in tension (or stress) causes decrease in strain resulting in decrease in λ_R $_1$✓

Variation due to motion:

As the lift accelerates downwards, (the tension is less than the weight in the cable, a decrease in tension results) in λ_R decreasing $_2$✓

At constant velocity (the tension again equals the weight and) λ_R returns to the initial, at rest value $_3$✓

Allow a correct comment on the directional relationship between tension, strain and λ_R independent of the motion of the lift for first mark

3

(c) **P** because it will produce a larger increase in λ_R for the (same) <u>increase</u> in strain

OR

P because it has a larger gradient (must be a sense of larger increase in λ_R for the (same) <u>increase</u> in strain) ✓

Hence <u>smaller accelerations</u> (which produce small changes in strain) can produce <u>measurable changes in λ_R</u>

OR

Hence gauge **P** will have a higher resolution ✓

Selecting Q gains zero marks

Linking steeper gradient to being able to withstand a larger force negates this mark

Allow more accurate measurement of <u>acceleration</u>

Allow more readings of <u>acceleration</u> can be taken (over the range)

More sensitive treat as neutral

2

[8]

Q3.

B

[1]

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Q4.

D

[1]

Q5.

(a) Substitution of data in $Y = \frac{FL}{A\varepsilon}$

3.1×10^{-3} (m) ✓

2 marks can be awarded if 4mm used to show T>500 N provided an explanation is provided, otherwise award zero.

2

(b) (500 = Tcos 65)

T = 1200 N ✓

1

(c) Wind produces a wave / disturbance that travels along the wire ✓

Wave is reflected at each end / waves travel in opposite directions ✓

(Incident and reflected) waves interfere / superpose ✓

Only certain frequencies since fixed ends have to be nodes. ✓

4

(d) Mass per m of the wire = 0.14(2) kg ✓

1

(e) Use of $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}} (= 2.47)$ to find fundamental

$(\text{or } f = \frac{3}{2l}\sqrt{\frac{T}{\mu}})$

Third harmonic = 7.4 (Hz) ✓

The second mark is for multiplying the fundamental frequency by 3 – allow ecf

2

(f) Diagram showing three approximately equally spaced loops

Condone single line

1

(g) Copper may be stretched beyond elastic limit / may deform plastically ✓

Permenant deformation / Does not return to original length ✓

Allow 'will remain longer than original' or 'will be permenantly

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deformed'

2

[13]

Q6.

B

[1]

Q7.

C

[1]

Q8.

B

[1]

Q9.

B

[1]

Q10.

A

[1]

Q11.

(a) Refers to relative direction of oscillations to that of the direction of propagation / transfer of energy ✓

For transverse waves oscillations are at right angles to direction of propagation while in longitudinal waves they are in the same direction ✓

allow direction the wave is travelling in

2

(b) Correct value for μ = (1 ×) $\frac{\pi d^2}{4}$ ρ = 7.5 × 10^{-4} (kg $m^{-1)}$ ✓

$\left(\text{uses } f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}\right)$ ✓

Tension = 126 N (allow 9.7 × 10^5 × their value for μ) ✓

2

(c) Max tension permissible before breaking = 3.0 × 10^9 ×

$\frac{\pi \times (3.5 \times 10^{-4})^2}{4}$ = 288 (289)(290) N ✓

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This is greater than required tension so wire is suitable. ✓

OR

stress in operation = $\frac{126 \times 4}{\pi \times (3.5 \times 10^{-4})^2}$ = 1.3 × 10^9 (N m^{-2})✓

which is less than breaking stress ∴ safe to use✓

Allow ecf for incorrect area in 2.2

2

(d) Shows second harmonic λ = $\frac{1}{f}\sqrt{\frac{T}{\mu}}$ ✓

Identify f and T are constant so λ is proportional to $\frac{1}{\sqrt{\mu}}$ ✓

λ increases from A to B ✓

mass per unit length decreases from A to B so A has a greater diameter✓

4

[10]

Q12.

C

[1]

Q19.

(a) tensile stress is the force exerted per/over <u>cross sectional area</u> ✓

can use equation but must define terms

1

tensile strain is the extension per/over <u>original length</u> ✓

NOT compared to

1

(b) material is brittle ✓

2nd mark dependent on first

1

shown on graph by little or no of plastic behaviour OR by
linear behaviour/straight line to breaking stress ✓
OR
material has high Young modulus OR material is stiff ✓
shown on graph by large gradient/steep line (compared to other materials) ✓

1

(c) area = π × $(1.5 \times 10^{-4})^2/4$ = 1.77 × 10^{-8} ✓

1

tensile force = 1.77 × 10^{-8} ✓

1

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= 23 (N) ✓

1

if use diameter as radius −1

if use incorrect formula (d^2 $2\pi r$ etc. −2)

range 22.5 – 24

power of ten error −1

if calculated area incorrectly get following answers

diameter as radius = 92 (2 marks)

d^2 = 7.3 (1 mark)

$2\pi r$ = 610 000 (1 mark)

if use d for area then zero

(d) **The mark scheme gives some guidance as to what statements are expected to be seen in a 1 or 2 mark (L1), 3 or 4 mark (L2) and 5 or 6 mark (L3) answer. Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist marking this question.**

Level 3

Correct materials selected for **each** application (B/C for lift and D for bungee). One reason for choices given for **each** application and explanation why at least one other material would be rejected for **each** application.

6

Correct materials selected for **each** application (B/C for lift and D for bungee). One reason for choices given for **each** application and explanation why at least one other material would be rejected for **one** application.

5

The student presents relevant information coherently, employing structure, style and sp&g to render meaning clear. The text is legible.

Level 2

Correct material selected for **one** application (B/C for lift and D for bungee). **One** reason for choice given for one application and explanation why at least one other material would be rejected for **one** application.

4

Correct material selected for **one** application (B/C for lift and D for bungee). **One** reason for choices given application.
OR
Correct materials selected for **each** application (B/C for lift and D for bungee). One reason for choices given for **each** application

3

The student presents relevant information and in a way which assists the communication of meaning. The text is legible. Sp&g are sufficiently accurate not to obscure meaning.

Level 1

No correct material selected but at least **two** properties necessary for an application given.

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2

No correct material selected but at least **one** property necessary for an application given.

1

The student presents some relevant information in a simple form. The text is usually legible. Sp&g allow meaning to be derived although errors are sometimes obstructive.

Level 0

No correct material selected and no properties necessary for an application given

The student's presentation, spelling and grammar seriously obstruct understanding.

0

The following statements may be present for cable supporting a lift

material B/C is used for the lift because it has a high breaking stress and a high Young modulus

material A not chosen because lower breaking stress

material A not chosen because fails without warning

material C not chosen because has a lower breaking stress

material D not chosen as larger increase in strain for a given increase in stress

material D not chosen as low breaking stress.

material D a given stress produces a large strain meaning large extension

The following statements may be present for rope or cable used for bungee jump

material D chosen as due large strain for given stress time taken to come to rest lengthens

material D is chosen because D can store a large amount of energy before failure

not A ,B or C because high Young Modulus so sudden stop resulting in large forces

not A as brittle and therefore limited strain and sudden failure

not C because requires a large strain before plastic behaviour

not C because if behaves plastically will not return to original length

[13]

Q20.

(a)

breaking stress	✓
stiffness constant, k	
tensile strain	

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tensile stress	
Young modulus	✓

1

(b) (i) elastic limit ✓

only one attempt at the answer is allowed

1

(ii) ($E = 300 \times 10^6 / 4 \times 10^{-2} = 7.5 \times 10^9$)

7.5 (Pa) ✓ allow 7.4 to 7.6 (Pa)

$\times 10^9$ ✓

first mark is for most significant digits ignoring the power of 10. E.g. 7500 gains mark

2

(c) straight line beginning on existing line at a strain of 0.10 and hitting the strain axis at a lower non-zero value ✓

line that ends on the x -axis with strain between 0.045 and 0.055 ✓(only allow if first mark is given)

ie accuracy required ± one division

2

(d) 8.99×10^{-3} (m^3) ✓ condone 1 sig fig

allow 9.00×10^{-3}

1

(e) $0.9872 \times 8.99 \times 10^{-3}$ or $= 8.8749 \times 10^{-3}$ (m^3) ✓

allow CE from 4d

($m = \rho V$)$= 2700 \times 8.8749 \times 10^{-3} = 24$ (kg) ✓ (23.962 kg)

allow CE from first part, e.g. if 1.28% was used gives 0.311 kg

$V = 0.9872 \times$ (d)

$m = 2.665 \times$ (d)

1.28% of vol = 1.15×10^{-4} m^3

2

[9]

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Q1.

This question required students to understand the conditions for equilibrium and apply these in a multi-step calculation. They were also required to understand the significance of the centre of mass..

(a) A pleasing proportion of students (nearly two-thirds) were able to identify one of the conditions for equilibrium; the resultant force being zero being the common answer. Only more able students were able to provide the second condition.

(b) There was some confusion over how centre of mass is defined. A significant proportion of students stated what is meant by the centre of gravity. This was given credit but it is clear that the distinction between these two is not well understood.

(c) Very few students (2.9%) managed to score both marks for this question. Nearly a quarter of students appreciated that this was to prevent rotation, but did not then give a complete explanation by referring to no resultant moment about A as the line of action of the forces passes through A when the beam is in equilibrium.

(d) This is not an unusual calculation at this level but it was clear that a significant proportion of students were unsure how to analyse the forces on the beam. The best students managed complete solutions whilst weaker students did manage to access some of the intermediate marks.

(e) The calculation in this question proved to be much more accessible and far more students were able to access the marks. Over half managed to score at least two marks. The most common error was failing to calculate the cross-sectional area correctly; the predominant mistake was using the diameter for radius. Weaker students often used surface area of the cable instead of cross-sectional area.

Q2.

(a) There were many good examples of work in this part from higher achieving students. On the other hand, lower achieving students had difficulty in following the question structure with many trying to find 97% of the speed of light in a vacuum rather than 97% of the speed of light in glass **A**. Another common mistake seen was students who simply multiplied n_a × 1.03252. This was another place in the paper where students failed to gain marks due to incorrect use of significant figures. Just over a third of students failed to gain any marks.

(b) Lower achieving students characteristically limited their answers to restating the relationship between λ_R and strain as shown in the graph. They were unable to make the link between the motion of the lift and its effect on strain and λ_R. Where students attempted to explain this connection, they often thought that the tension in the cable increased as the lift accelerated downwards. Only 7.4% of students scored two or three marks.

(c) Many students presented answers that addressed the strength of the cable and its ability to withstand larger stress rather than the ability of the sensor to detect small changes in the acceleration. Two-thirds of students who attempted the question failed to gain any marks here.

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Q3.

42.7% of students selected the correct answer, showing a greater competency for manipulation of formulae when numerical data has been provided.

Q4.

44.5% correct

Q5.

This question applied both the idea of standing waves and the behaviour of materials to the context of a radio aerial. Despite this combination of topics, several parts of the question proved to be very accessible.

(a) It is clear from the large proportion of students who obtained both marks for this question that the application of the Young modulus is well understood. This question was made even more accessible by providing the area, and by giving all the data in units that did not require conversion.

(b) This one mark calculation was poorly answered, with few students being able to obtain the correct value for the tension. It may be that many students missed the relevant data or could not picture which forces were needed. It would doubtless have helped some students had they drawn the forces on the diagram provided.

(c) It is clear that many students learn about the formation of standing waves in general terms and answers focusing on this were incomplete in several respects. In particular, many students missed out the initial formation of the wave, and many failed to adequately explain the reason for production of specific frequencies. Consequently it was common to see answers obtaining only 2 of the 4 marks.

(d) This calculation proved to be very accessible with a large majority of students obtaining the single mark for it.

(e) However, this calculation proved to be less accessible despite an error for the mass per unit length in part (d) being carried forward. Credit was also given for students making it clear that the fundamental frequency had to be multiplied by 3.

(f) The drawing of three ‘loops’ was generally awarded the mark, unless the length of each loop was too unequal to be acceptable.

(g) Whilst it was common to see answers that made some attempt to describe what happens to the wire if it is stretched too much, poor use of the correct terminology, such as failure to mention an elastic limit or equivalent, tended to limit the mark awarded to many answers.

Q6.

91% of students selected the correct answer.

Q7.

30% of students opted for distractor D; this was mostly due to having eliminated distractors A and B, and guessing between C and D. The majority of those who attempted an analysis of base units did this correctly, recognising that distractor D was a permissible unit.

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Q8.

Most students selected the correct answer. A significant number of students selected distractor D, believing this statement was incorrect. **X** has a greater breaking stress since the force applied to it is greater than the force applied to **Y** at the point of breaking.

Q19.

Part (a) required students to state the meaning of tensile stress and tensile strain. Marks were frequently lost due to a lack of precision in technical language. For example it was common to see force per unit area rather than cross-sectional area and change in length per length rather than extension per original length. In (b) a significant proportion of students were able to select an appropriate property for material but only about half of those correctly identifying the property were then able to give a suitable explanation. The calculation in part (c) was well done with over half the students being awarded full marks. The main errors were an incorrect calculation of cross-sectional area due to using the diameter as a radius or a power of ten error when using GPa. Question 3.4 was a level of response marked question and some very impressive answers were seen. About 30% of students were placed in the top band. Some answers were spoilt when students did not give complete answers. This was because although they correctly identified the material for the applications they did not explain why other materials would be rejected. Generally students were more successful in the selection of material for the lift cable than they were for the rope for bungee jumping. This was in part due to them thinking that in order for a material to be elastic it had to obey Hooke's law and thus have linear stress strain characteristics. This led them to think that material D was not behaving elastically and therefore should be rejected for both applications. Overall however, this question seemed to generate better answers than has been the case with extended prose questions in previous specifications.

Q20.

On the whole this question was a good discriminator. In (a) a high proportion of the students did not know which terms referred to the property of a material and hence be independent of the materials' shape. The straightforward question (b)(i) based on simple recall of the term 'elastic limit', was scored by less than half the students. 'Limit of Proportionality', was the most common wrong answer.

(b)(ii) gave a good spread of marks. Of those that missed one mark out of the two available half chose to calculate the Young modulus using a non-linear part of the graph and the other half made errors in the powers of 10 in the calculation. These students were confused or missed the unit MPa. A majority of students did not know what happens to a stress-strain graph during unloading as was evident from answers to (c). Most that had genuine attempts at the question thought the graph should eventually end up at the origin. The others either got the question correct or they drew very random lines which in many cases did not start from the existing graph or had a shape that had no association with the existing graph.

(d) was performed well and a majority of students had a good attempt at it. The weaker students sometimes found the mass of copper and presented this as an answer or they incorrectly found 1.28% of the mass of aluminium rather than calculate this percentage of its volume.

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