AQA A-LEVEL PHYSICS · 7408

PHYSICS



EXAM QUESTION PACK

3.4.2 MATERIALS

SCORE	PERCENTAGE
/73	%

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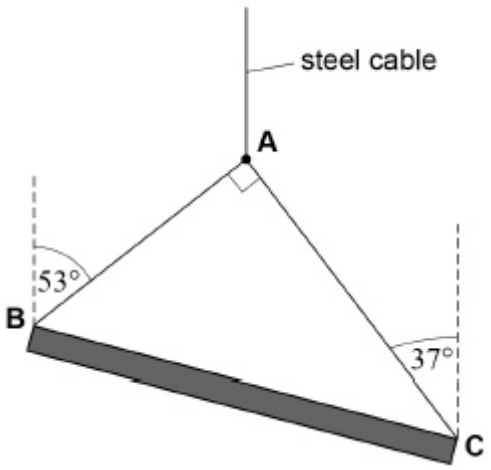
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Q1.

The diagram shows a uniform beam supported by two light cables, **AB** and **AC**, which are attached to a single steel cable from a crane. The beam is stationary and in equilibrium.



(a) State **two** necessary conditions for the beam to be in equilibrium.

Condition 1 _____

_____

_____

Condition 2 _____

_____

_____

(2)

(b) State what is meant by the centre of mass.

_____

_____

(1)

(c) Explain why the centre of mass of the beam in the diagram must be vertically below **A**.

_____

_____

_____

_____

(2)

(d) The weight of the beam is 12 000 N

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Calculate the tension T_1 in cable **AB** and the tension T_2 in cable **AC**.

T_1 = _____ N

T_2 = _____ N

(4)

(e) The steel cable from the crane has a circular cross-section of diameter 1.5×10^{-2} m
The cable is 12 m long.

Calculate the extension of the cable caused by the weight of the beam. You can assume that the weights of **all cables** are negligible.

Young modulus of steel = 2.0×10^{11} Pa

extension = _____ m

(3)

(Total 12 marks)

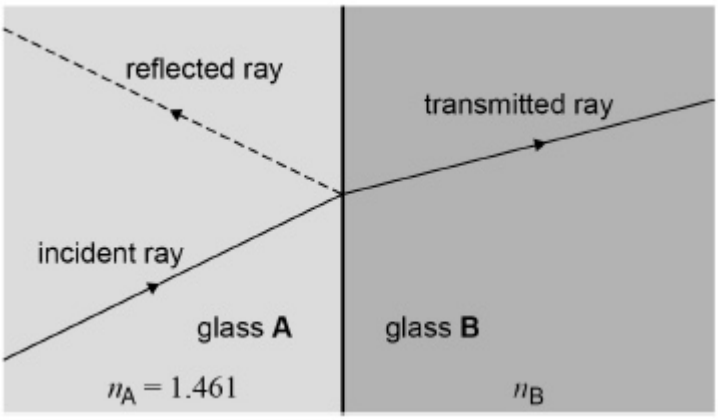
Q2.

(a) **Figure 1** shows an incident ray of light being partially reflected at the boundary between glass **A** and glass **B**. The refractive index n_A of glass **A** is 1.461

The speed of light in glass **B** is 3.252% less than the speed of light in glass **A**.

Figure 1

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Calculate the refractive index n_B of glass **B**.

Give your answer to an appropriate number of significant figures.

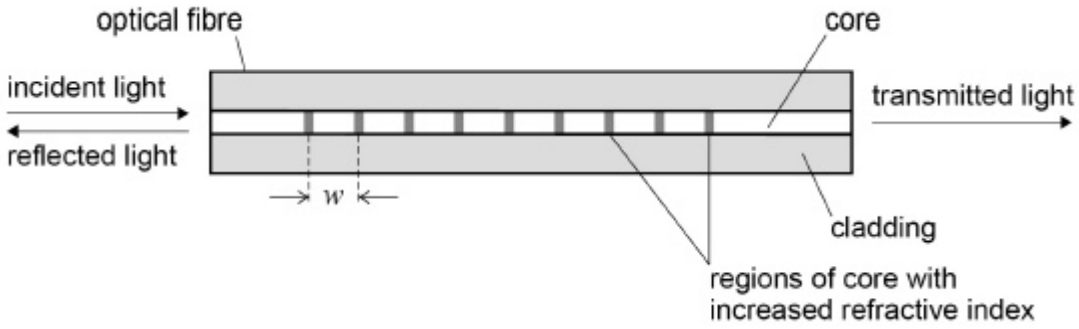
speed of light in a vacuum = 2.998×10^8 m s^{-1}

n_B = _____

(3)

(b) **Figure 2** shows a cross-sectional view of an optical fibre strain gauge.

Figure 2



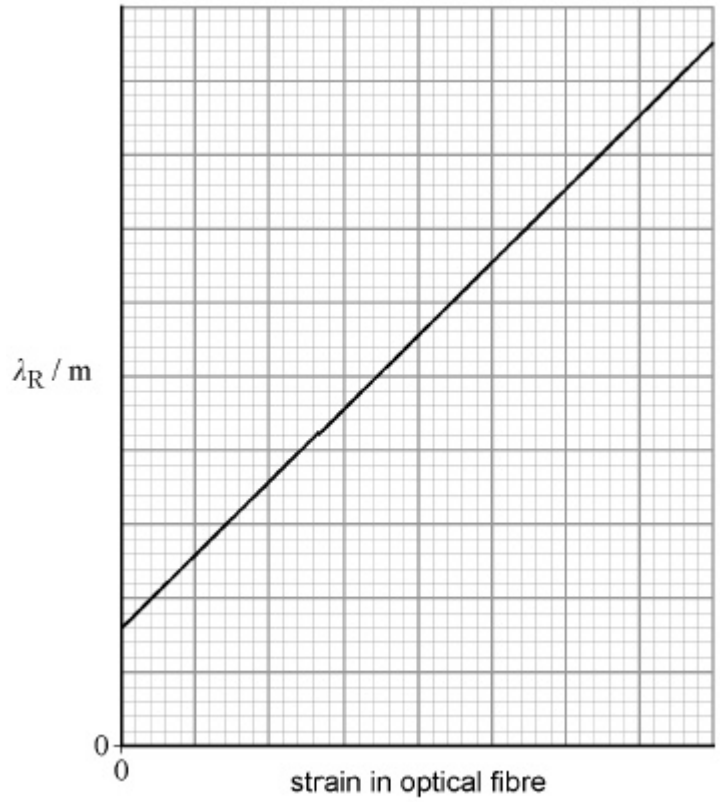
A maximum intensity of the reflected light is produced due to superposition of the light reflected from each of the regions with increased refractive index in the core.

This maximum intensity occurs at a particular wavelength λ_R.

Figure 3 shows the relationship between λ_R and the strain in the optical fibre.

Figure 3

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A cable is used to raise and lower a lift. An engineer fixes the optical fibre strain gauge to the cable to monitor changes of the strain in the cable.

The lift is initially at rest and then accelerates downwards for a short time before reaching a constant velocity.

Discuss how the value of λ_R changes.

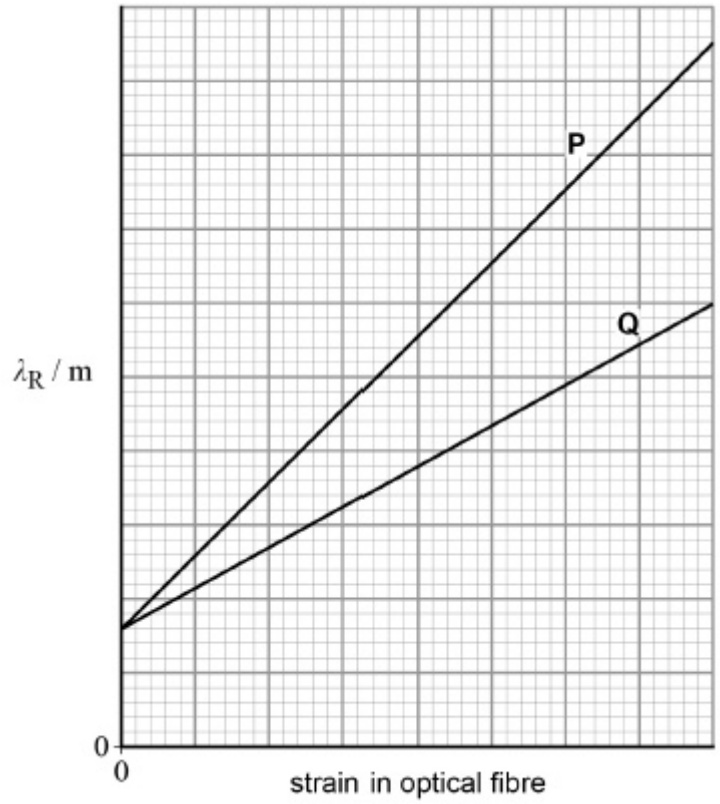
(3)

(c) **Figure 4** shows the relationship between λ_R and the strain in two optical fibre strain gauges **P** and **Q**. The engineer wishes to measure small accelerations in another lift. She can choose to fix either optical fibre strain gauge **P** or optical fibre

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strain gauge **Q** to the lift's cable.

Figure 4



Explain which gauge the engineer should select.

(2)
(Total 8 marks)

Q3.

The table contains information on four wires. It shows the stiffness of each wire and the maximum strain energy stored in the wire when extended to the breaking point.

Assume each wire has the same initial dimensions and obeys Hooke's law.

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Which wire extends the least before reaching the breaking point?

	Stiffness / N m^{-1}	Maximum strain energy / J	
A	4.0	1	⬭
B	9.0	1	⬭
C	16	3	⬭
D	25	3	⬭

(Total 1 mark)

Q4.

A steel wire **W** has a length l and a circular cross-section of radius r. When **W** hangs vertically and a load is attached to the bottom end, it extends by e.
Another wire **X** made from the same material has the same load attached to it.

Which length and radius for **X** will produce an extension of $\frac{e}{4}$?

	Length of X	Radius of X	
A	$0.5l$	$2r$	⬭
B	l	$4r$	⬭
C	$2l$	$2r$	⬭
D	$4l$	$4r$	⬭

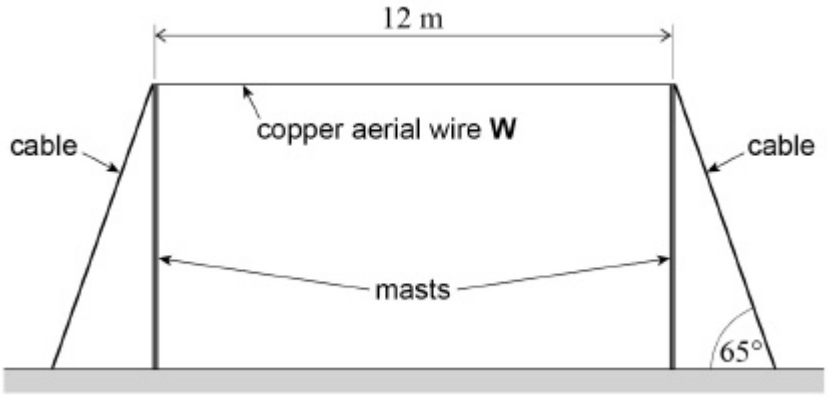
(Total 1 mark)

Q5.

Figure 1 shows a structure that supports a horizontal copper aerial wire **W** used for transmitting radio signals.

Figure 1

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The copper aerial wire is 12 m long and its area of cross-section is 1.6×10^{-5} m^2.
The tension in the copper aerial wire is 5.0×10^2 N.

Young modulus of copper = 1.2×10^{11} Pa

(a) Show that the extension produced in a 12 m length of the aerial wire when the tension is 5.0×10^2 N is less than 4 mm.

(2)

(b) The cables that support each mast are at an angle of 65° to the horizontal.

Calculate the tension in each supporting cable so that there is no resultant horizontal force on either mast.

tension = _____ N

(1)

(c) When wind blows, stationary waves can be formed on the aerial wire.

Explain how stationary waves are produced and why only waves of specific frequencies can form on the aerial wire.

_____

_____

_____

_____

_____

_____

_____

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_____

(4)

(d) Calculate the mass of a 1.0 m length of the aerial wire.

Density of copper = 8900 kg m^{-3}

mass = _____ kg

(1)

(e) Calculate the frequency of the wave when the third harmonic is formed on the aerial wire.

frequency = _____ Hz

(2)

(f) Sketch, on **Figure 2**, the standing wave on the wire when the third harmonic is formed.

Figure 2



(1)

(g) High winds produce large amplitudes of vibration of the aerial wire.

Explain why the wire may sag when the high wind stops.

_____

_____

_____

_____

(2)

(Total 13 marks)

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Q6.

What is the name given to a material that breaks without deformation when a force is applied to it?

A Plastic ⬭

B Brittle ⬭

C Stiff ⬭

D Elastic ⬭

(Total 1 mark)

Q7.

What **cannot** be used as a unit for the Young modulus?

A N m^{-2} ⬭

B Pa ⬭

C kg m^{-2} s^{-2} ⬭

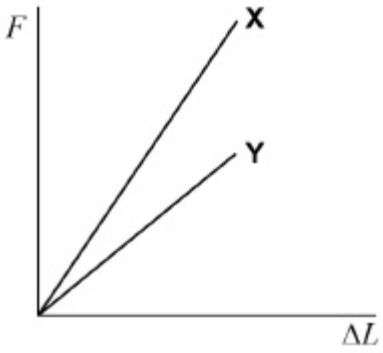
D kg m^{-1} s^{-2} ⬭

(Total 1 mark)

Q8.

Two separate wires **X** and **Y** have the same original length and cross-sectional area.

The graph shows the extension ΔL produced in **X** and **Y** when the tensile force F applied to the wires is increased up to the point where they break.



Which statement is **incorrect**?

A For a given extension more energy is stored in **X** than in **Y**. ⬭

B The Young modulus of the material of wire **Y** is greater than that of wire **X**. ⬭

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C Both wire **X** and wire **Y** obey Hooke's law. ⬭

D Wire **X** has a greater breaking stress than wire **Y**. ⬭

(Total 1 mark)

Q9.

A sample of wire has a Young modulus E. A second sample of wire made from an identical material has three times the length and half the diameter of the first sample.

What is the Young modulus of the second sample of wire in terms of E?

A $0.25E$ ⬭

B E ⬭

C $6E$ ⬭

D $12E$ ⬭

(Total 1 mark)

Q10.

A wire of length L and cross-sectional area A is stretched a distance e by a tensile force. The Young modulus of the material of the wire is E.

Which expression gives the elastic energy stored in the stretched wire?

A $\frac{1}{2}\frac{EAe^2}{L}$ ⬭

B $\frac{1}{2}\frac{L}{Ae}$ ⬭

C $\frac{1}{2}\frac{Ae^2}{EL}$ ⬭

D $\frac{1}{2}\frac{EAL}{e}$ ⬭

(Total 1 mark)

Q11.

(a) Distinguish between longitudinal and transverse waves.

_____

_____

_____

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(2)

(b) A piano repairer replaces the wire that produces the highest note on a piano. The wire has a vibrating length of 0.050 m. He uses a wire with the following properties:

diameter = 3.5×10^{-4} m
density = 7.8×10^{3} kg m^{-3}
breaking stress = 3.0×10^{9} N m^{-2}

Calculate the tension required for the vibrating wire to produce its correct frequency of 4.1 kHz.

tension = _____ N

(2)

(c) Evaluate, using the data provided in part **(b)**, whether it is safe to use this wire.

(2)

(d) The repairer uses faulty wire so that the diameter of the wire increases linearly with distance along its length. The profile of the vibration produced when the wire sounds its second harmonic is shown in the diagram below.



The speed c of a transverse progressive wave travelling along a string of mass per unit length μ and under tension T is given by

$$c = \sqrt{\frac{T}{\mu}}$$

Explain which end of the wire, **A** or **B**, has the greater diameter and why the profile

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of the stationary wave has the shape shown in the diagram above.

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 10 marks)

Q12.

A steel wire has a cross-sectional area 0.5 mm^2. The Young modulus of steel is 2.0×10^{11} Pa. Assume the wire obeys Hooke's law.

What load must be suspended from the wire to produce an extension which is 0.1% of the original length?

A 40 N ⬭

B 50 N ⬭

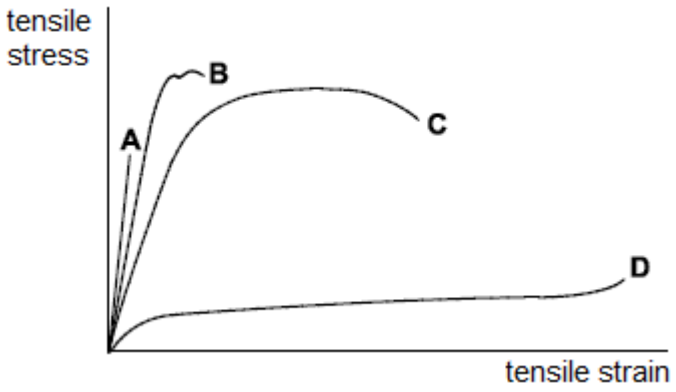
C 100 N ⬭

D 200 N ⬭

(Total 1 mark)

Q19.

The diagram below shows the tensile stress–tensile strain graphs for four materials, **A**, **B**, **C** and **D**, up to their breaking stress.



(a) State what is meant by tensile stress and tensile strain.

tensile stress _____

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tensile strain _____

(2)

(b) Identify a property of material **A** using evidence from the graph to support your choice.

property _____

evidence _____

(2)

(c) A cylindrical specimen of material **A** under test has a diameter of 1.5×10^{-4} m and a breaking stress of 1.3 GPa.

Calculate the tensile force acting on the specimen at its breaking point.

tensile force = _____ N

(3)

(d) Discuss which of the four materials shown on the graph is most suitable for each of the following applications:

- the cable supporting a lift in a tall building
- a rope or cable attached to a person doing a bungee jump.

For each application, you should discuss the reason for your choice and why you rejected the other materials.

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_____

_____

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_____

_____

_____

(6)

(Total 13 marks)

Q20.

An aerospace engineer has built two differently designed wings. One wing is made from an aluminium alloy and the other is made from a carbon fibre composite.

The engineer tests a sample of each material by applying a varying stress.

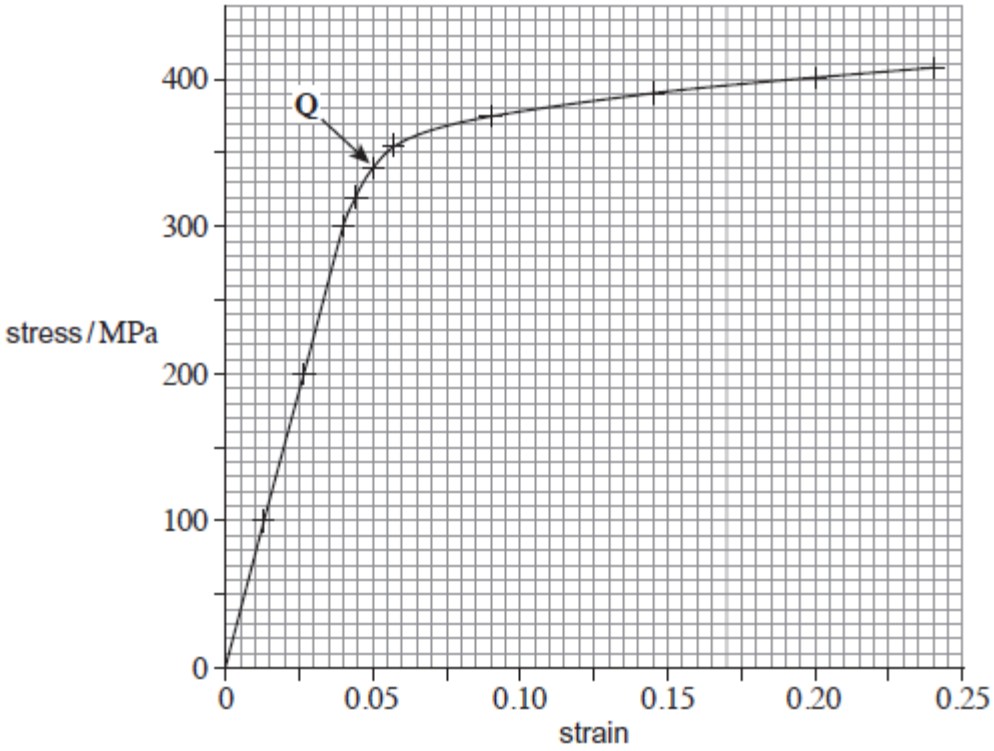
(a) Tick (✓) **two** of the boxes in the table below to indicate which are properties of the material from which the wing is made.

breaking stress	
stiffness constant, k	
tensile strain	
tensile stress	
Young modulus	

(1)

(b) Below is the stress−strain graph that the engineer obtains for the aluminium alloy.

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(i) The engineer has labelled a point **Q** on the graph. This is a point beyond which the behaviour of the material changes irreversibly. State the name for this point.

_____

(1)

(ii) Use the graph to determine the Young modulus of the aluminium alloy. Show your working.

Young modulus = _____ Pa

(2)

(c) The engineer who carried out the experiment to obtain the stress−strain graph decided to stretch another sample to a strain of 0.10. She then gradually reduced the stress to zero.

Show by drawing on the graph how you would expect the stress to vary with strain as the stress is reduced.

(2)

(d) Calculate the volume of 25.0 kg of the aluminium alloy.

density of aluminium alloy = 2.78×10^3 kg m^{-3}.

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volume = _____ m^3

(1)

(e) 1.28% of the aluminium alloy's volume is copper.
Calculate the mass of pure aluminium needed to make 25.0 kg of the aluminium alloy.

density of pure aluminium = 2.70×10^3 kg m^{-3}.

mass of pure aluminium = _____ kg

(2)

(Total 9 marks)

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