Examiner only

5. *(a)* (i) Draw a labelled diagram of the apparatus you could use to determine the relationship between the resistance and length of a wire. [3]

(ii) State what measurements you need to make. [2]

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(iii) What further measurement would you need to make to determine the resistivity of the metal and what apparatus would you use to make this measurement? [1]

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(iv) Explain how a value of the resistivity is determined from your measurements. [3]

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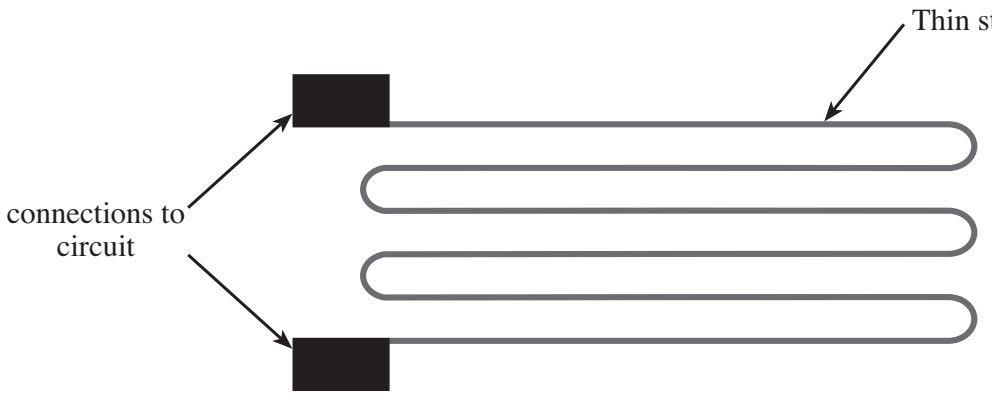
Examiner only

(b) A strain gauge is a device used to monitor distortions in structures such as bridges and buildings. It consists of a thin strip of metal wire as shown which is then attached to the structure under test.



(i) When the structure extends, the wire in the strain gauge gets **thinner** and **longer** thus changing its resistance. Using the resistivity equation explain whether the resistance of the strain gauge increases or decreases when the structure extends. [4]

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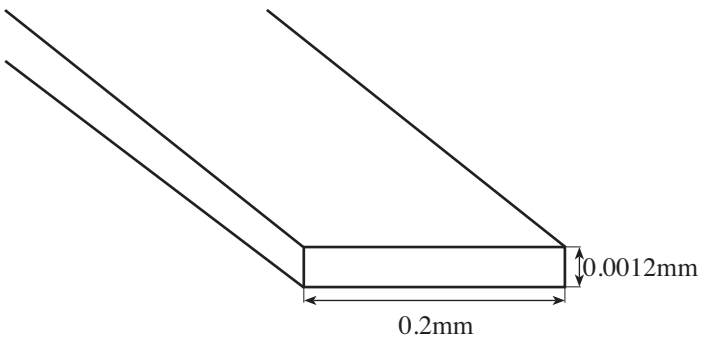
(ii) Calculate the resistivity of the metal in a strain gauge which has a resistance of 650 Ω and a total length of 32 cm. The thin metal strip is 0.2 mm wide and 0.0012 mm thick as shown. [2]



Thin metal strip (magnified - not to scale)

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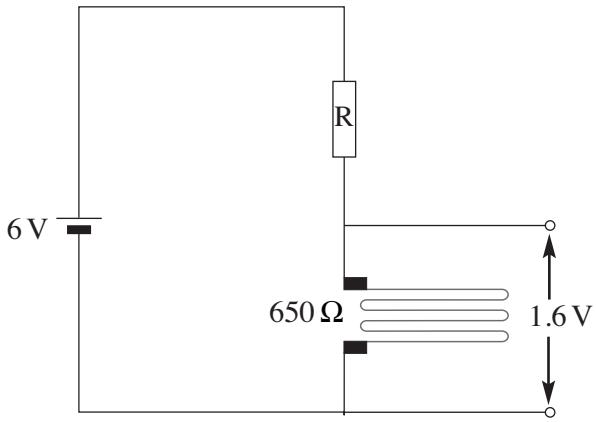
(iii) The changing resistance of a strain gauge is monitored using a potential divider circuit. The gauge is placed in series with a fixed resistor R as shown. Calculate the value of R which will give a p.d. of 1.6 V across the strain gauge. [3]



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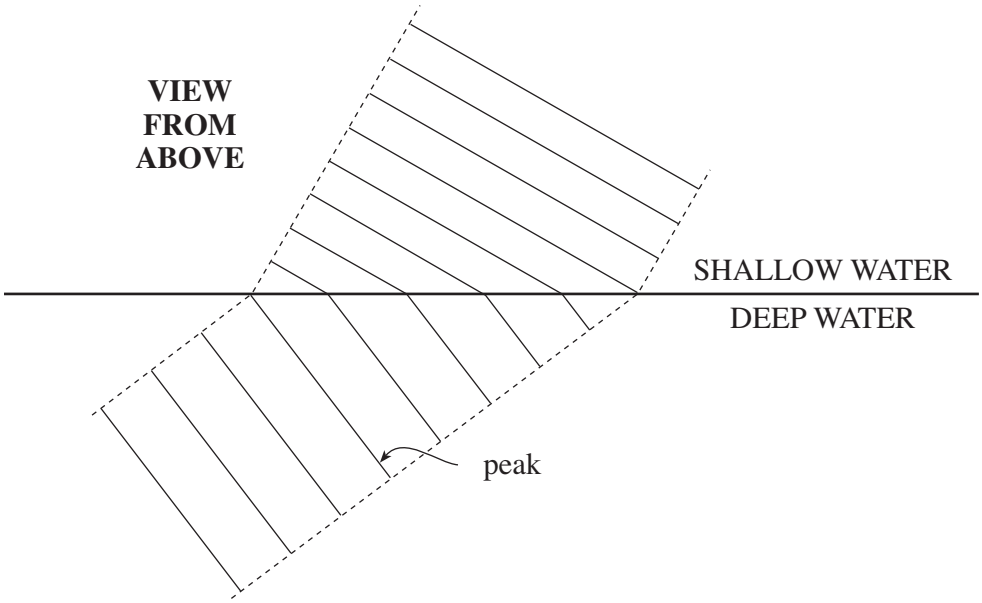
Examiner only

1. *(a)* Water waves are travelling into shallow water from deeper water. The actual positions of the wave peaks at one instant are shown on the diagram, **which is full size**.



(i) (I) Add two arrows to the diagram to show the directions of travel of the waves in the deep water and in the shallow water. [1]

(II) Deduce **from the change in direction** whether the waves travel faster or slower in shallow water. Give a reason. Calculations are not wanted. [2]

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(ii) (I) Measure the *wavelength* of the waves in the deep water. [1]

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(II) The *speed* of the waves in the deep water is $0.33\ \text{ms}^{-1}$. Calculate the frequency of the waves. [2]

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(III) Determine the speed of the waves in the shallow water. [2]

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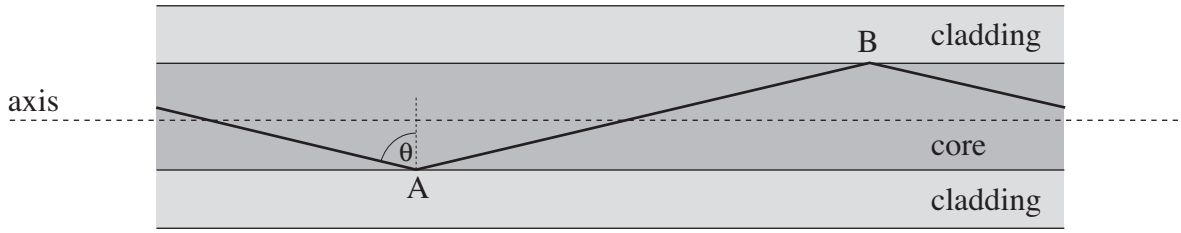
Examiner only

(b) The diagram shows a path by which light can travel through the core of a 'thick' glass fibre.



(i) Give the full name for the process which must occur at A and B if the light is to travel a large distance through the fibre along this path. [1]

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(ii) The smallest value of angle θ for which the process can take place is 72°. Calculate the refractive index of the cladding if that of the core is 1.58. [3]

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(iii) Thick glass fibres allow light to travel in zigzag paths, with a range of angles, and also in straight paths parallel to the fibre axis. Explain why these fibres are unsuitable for the transmission of rapid streams of data encoded in the light. [2]

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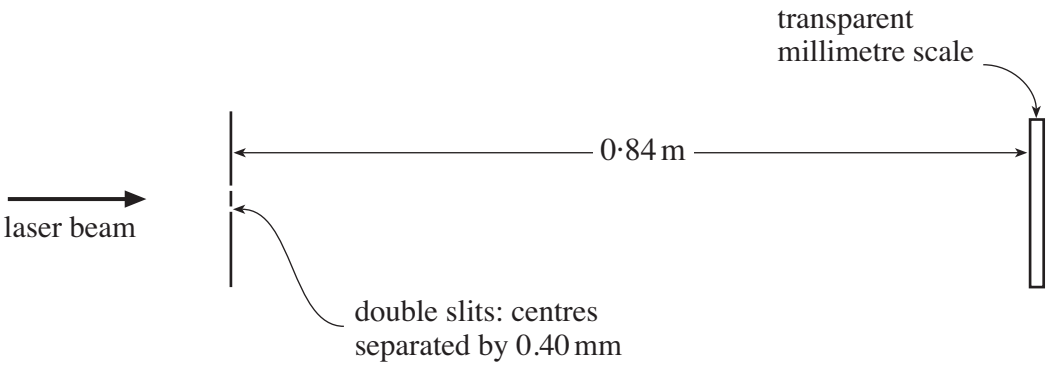
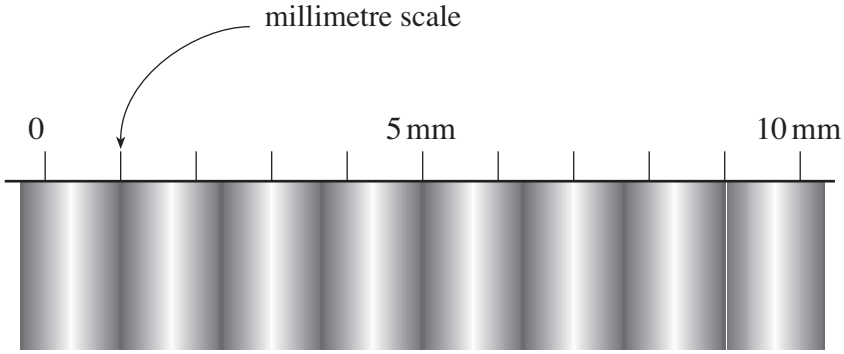
Examiner only

2. *(a)* Young's fringes are produced using light from a laser.



A transparent millimetre scale is placed 0.84 m from the double slits, as shown. When a camera is used to take a close-up picture of the scale, a series of equally-spaced bright and dark fringes is seen, as shown in the diagram below.



(i) Explain, in terms of *interference, phase* and *path difference*, how the **bright** fringes arise. [4]

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(ii) Using data from the diagrams calculate the wavelength of the light. [3]

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Examiner only

(b) The laser beam is now shone normally (i.e. at 90 °) at a diffraction grating with 5.00×10^5 'slits' per metre of length.

(i) Calculate the separation of the centres of adjacent slits in the grating. [1]

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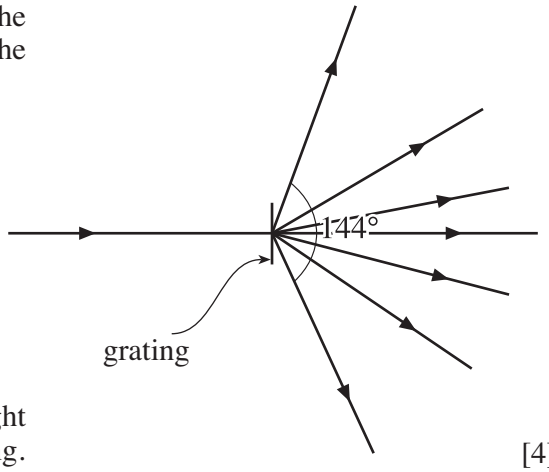
(ii) Seven beams emerge from the grating. The central lines of the beams are shown in the diagram.



Calculate the wavelength of the laser light using the angle given. Show your working. [4]

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(c) Suppose that you have to make your own measurements to find the wavelength of light from a laser. Discuss whether you would choose the Young's fringes method, or the diffraction grating method, if you wanted an accurate value for the wavelength. [2]

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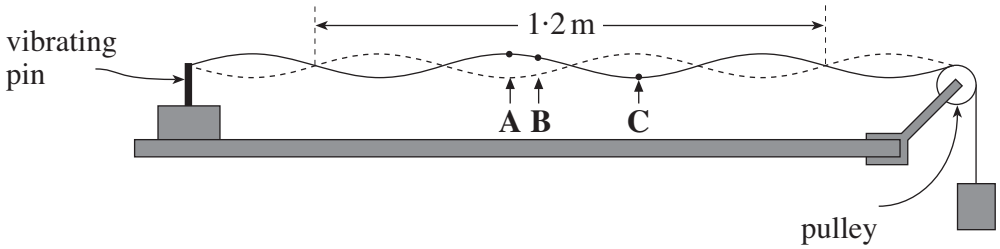
Examiner only

3. The diagram shows a demonstration of a *stationary wave* on a string.



(a) (i) State whether the following pairs of points on the string are vibrating *in phase*, *in antiphase*, or neither in phase nor in antiphase. [2]

A and **B** .....

A and **C** .....

(ii) Describe briefly how you could check this experimentally. [2]

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(b) (i) Progressive waves transfer energy through the medium; stationary waves do not do this. Describe **one** other difference between progressive and stationary waves. [2]

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(ii) Explain how, in the set-up above, the stationary wave can be thought of as arising from progressive waves. [2]

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Examiner only

(c) (i) From the diagram deduce a value for the wavelength. [1]

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(ii) The pin is vibrating at a frequency of 50 Hz. Calculate the wave speed. [1]

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Examiner only

4. *(a)* Einstein's *photoelectric equation* may be written

$$E_{\text{k max}} = hf - \phi .$$

(i) What quantity of energy does hf represent? [1]

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(ii) A student mistakenly thinks that the 'minus' sign should be a 'plus' sign. Explain, in terms of electrons and photons, why the equation must be correct as written above. [3]

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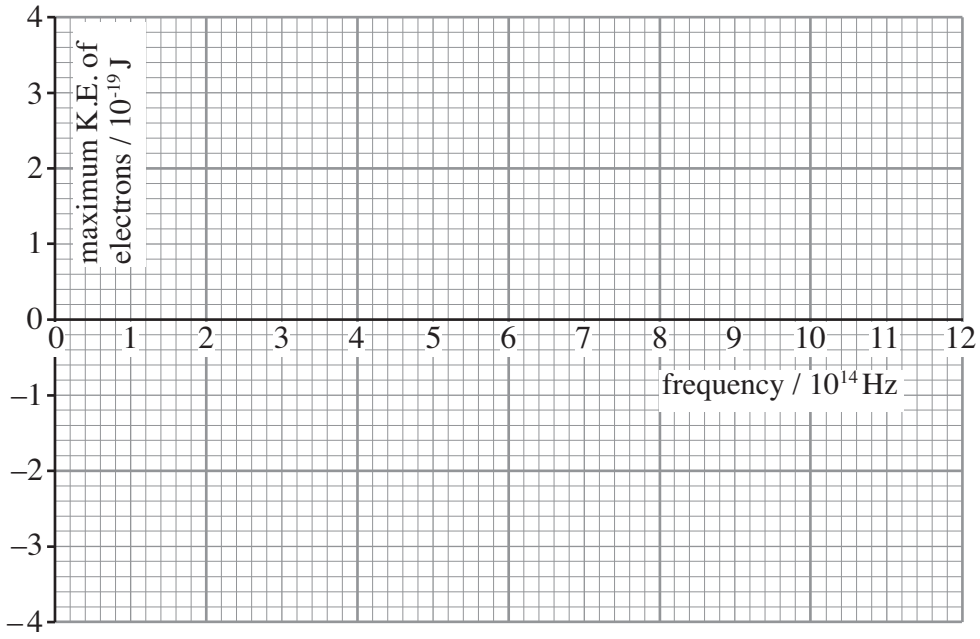
(b) In an experiment in which a sodium surface is exposed to electromagnetic radiation, these results are obtained.

f / 10^{14} Hz	6.9	9.6	11.8
$E_{\text{k max}}$ / 10^{-19} J	0.79	2.58	4.04

(i) Plot these data points on the grid, and hence draw the graph line. [2]



Examiner only

(ii) Use the data, or your graph, to determine values for

(I) the *work function* of sodium, [1]

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(II) the *Planck constant*. Show your working. [2]

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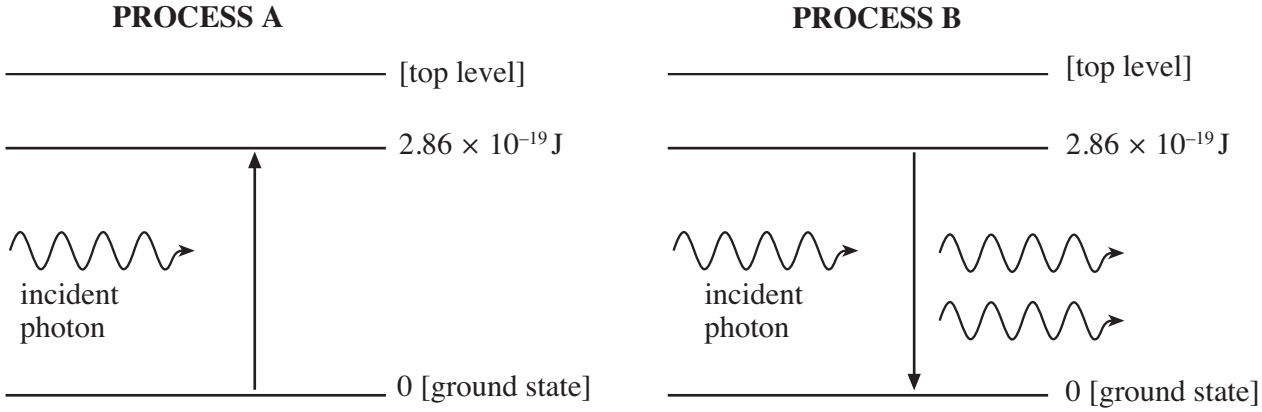
(iii) Draw on the grid a line, labelled (iii), which might be obtained if a metal with a **lower** work function were used in the experiment. [2]

Examiner only

5. A *ruby laser* is classed as a *3-level system*. The amplifying medium is a ruby, which is a crystal containing chromium ions. The diagram shows two processes, **A** and **B**, which could occur when a photon of a certain wavelength is incident on a chromium ion.



(a) Calculate the *wavelength* of the incident photon. [2]

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(b) (i) What name is given to process **A**? ..... [1]

(ii) State what happens to the energy of the incident photon in process **A**. [1]

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(c) (i) What name is given to process **B**? ..... [1]

(ii) State **two** things which the emerging photons in process **B** have in common. [2]

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(d) For the laser to work, process **B** must happen more often than process **A**. This requires a *population inversion*.

(i) Explain what is meant by a *population inversion*. [1]

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Examiner only

(ii) The population inversion is achieved in the ruby laser by *optical pumping* (shining a very bright light on the ruby). **Draw an arrow** on the right hand diagram on page 10 to represent the energy level transition associated with the pumping. [1]

(iii) How must the typical time an electron spends at the top level compare with the typical time it spends at the middle level? Give a reason for your answer. [2]

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