Examiner only

3. *(a)* What is a *superconductor*? [1]

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(b) With the aid of a sketch graph, explain the term *superconducting transition temperature.* [3]

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(c) Explain why superconductors are useful for applications which require large electric currents and name **one** such application. [2]

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Examiner only

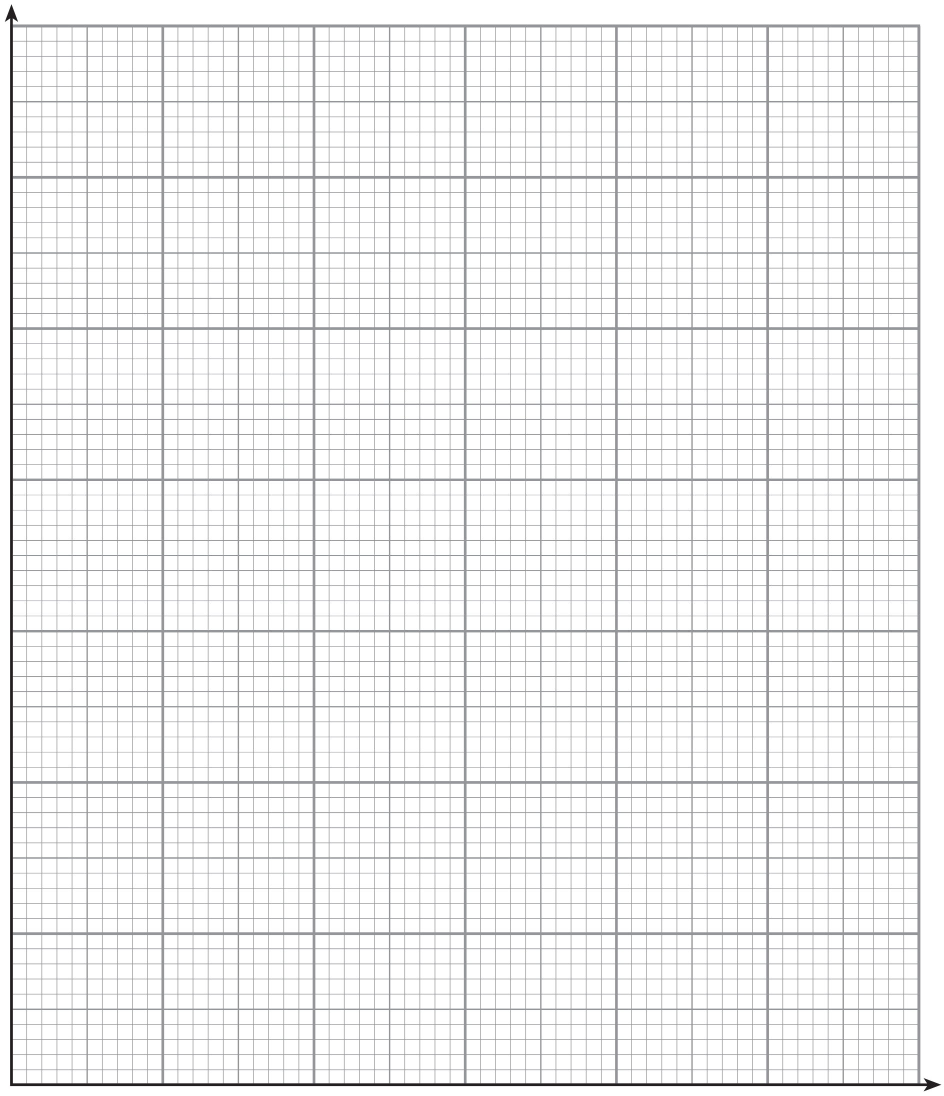
4. A student measures the potential difference across a metal wire for a range of current values.

(a) Draw a diagram of a circuit which could be used. [2]

(b) (i) The table below shows the results obtained. Complete the column labelled 'Resistance'. [1]

Current/A	p.d./V	Resistance / Ω
0.10	0.40	
0.20	0.80	
0.30	1.30	
0.40	1.90	
0.50	3.00	

(ii) Draw a graph of **resistance** (y-axis) against **current** (x-axis). [3]



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(c) (i) Describe how the resistance of the wire varies with current. [2]

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(ii) Give the range of currents over which Ohm's law applies to the wire. [1]

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(iii) Explain why Ohm's law does not apply outside this range. [1]

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(d) In an electric fire current flows through a wire called an element. An ammeter is placed in series with the element. Predict what would happen to the ammeter reading from the time the fire is switched on until it reaches a steady operating temperature. [2]

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Examiner only

8. *(a)* *Copper is an electrical conductor*. Explain what this statement means. [1]

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(b) (i) The density of copper is 8920 kgm^{-3}. Calculate the mass of a copper wire that has a cross-sectional area of 2.0×10^{-6} m^2 and is 2.0 m long. [2]

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(ii) Determine the **total** number of free electrons in this wire given that an atom of copper has a mass of 1.05×10^{-25} kg and each atom contributes, on average, 1.5 electrons. [2]

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(iii) Calculate the mean drift velocity of the electrons in the wire when there is a current of 1.2 A. [4]

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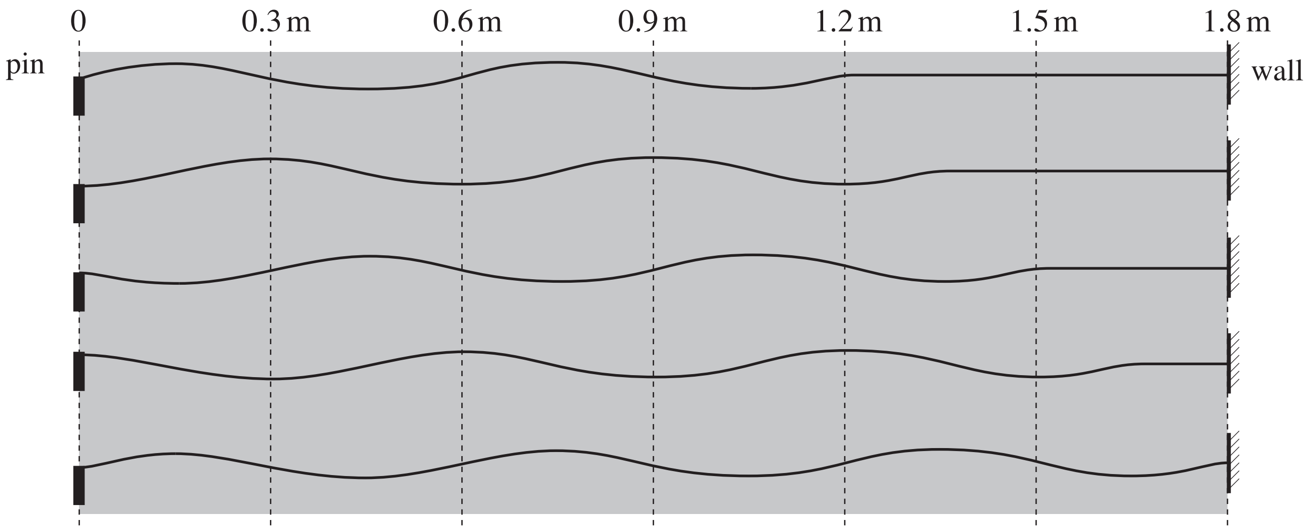
Examiner only

1. A piece of string 1.8 m long is attached at one end to the pin of a vibration generator and, at the other end, to a rigid wall. The diagrams show the string at intervals of 0.0030 s, starting from shortly after the generator has been connected to the signal generator (so the wave has not yet reached the wall).



(a) Calculate

(i) the *speed* of the waves, [2]

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(ii) the *frequency*. [3]

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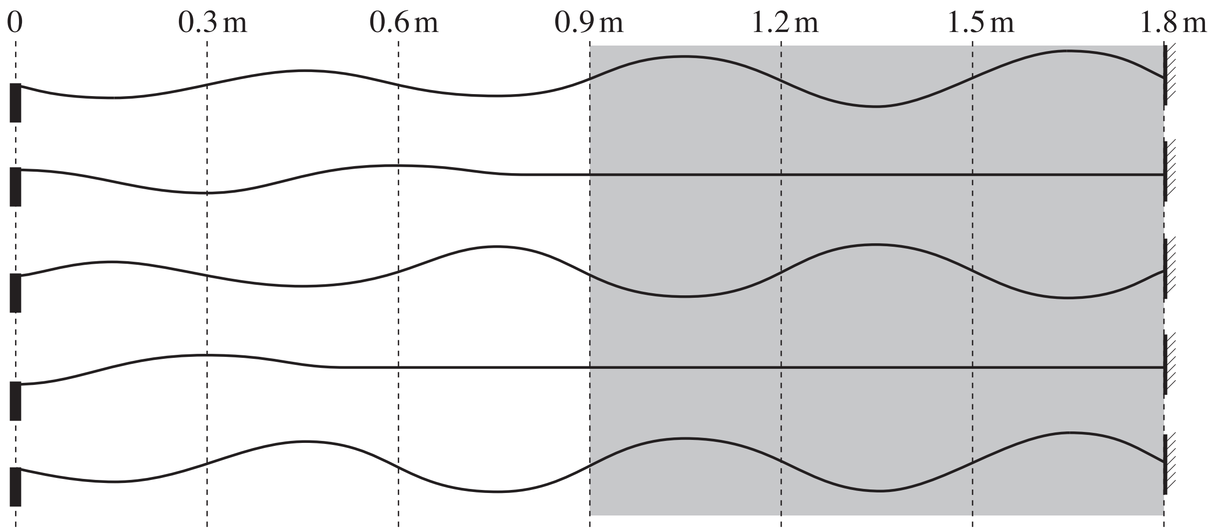
Examiner only

(b) Later on a *stationary wave* develops. **Refer to the shaded area below.**



(i) Write down two distances from the generator at which there are *nodes.* [1]

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(ii) (I) Describe how the *amplitude* of the stationary wave varies with distance along the string. [2]

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(II) Explain whether or not the same description applies to the amplitude of the *progressive* wave (see previous page). [1]

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(c) Explain in terms of *interference* how the stationary wave is formed and, in particular, how *nodes* arise. [3]

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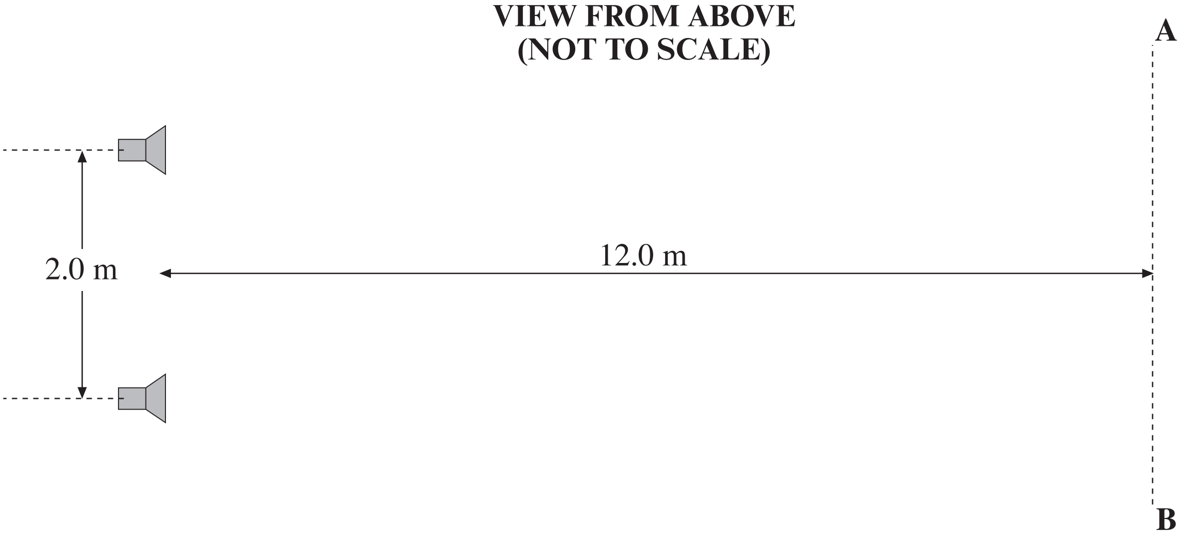
1322 01 03

2. Two loudspeakers are placed 2.0 m apart, and facing the same way, in the middle of a playing field, on a calm day. They are connected to the same signal generator, and therefore produce sound of the same frequency.

VIEW FROM ABOVE
(NOT TO SCALE)



(a) A student walks slowly along the line **AB**, and hears the sound varying regularly in loudness as he walks. The positions where the sound is loudest are 1.8 m apart.

(i) Use the *Young's fringes* formula to calculate the wavelength of the sound. [2]

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(ii) Suggest why the results would be less reliable if the experiment were performed in a hall, that is surrounded by walls. [1]

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(b) The student now stops at a point where the sound is quietest. The teacher then disconnects **one** of the loudspeakers. The student now hears a louder sound. Explain why the sound is louder. Your answer should mention *phase*. [3]

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(c) The disconnected loudspeaker is reconnected, but with the wires to its terminals swapped over, so that the loudspeakers are now sound sources in *antiphase* (exactly out of phase). What difference will be observed by the student if he repeats the walk of part *(a)*? [1]

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(d) State, giving your reasoning, how the separation between points of quietest sound along AB would change if

(i) the separation of the loudspeakers were doubled (to 4.0 m), [2]

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(ii) the signal generator were adjusted so that the ***frequency*** of sound emitted by the loudspeakers were doubled. [The loudspeaker separation is restored to 2.0 m] [2]

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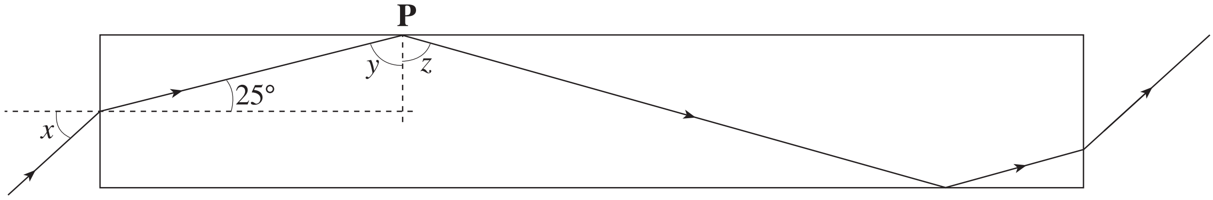
1322 01 05

Examiner only

3. A student directs a narrow beam of light on to one end of a glass block, as shown.



(a) (i) Referring to the diagram, calculate the angle of incidence, *x*. [Refractive index of air = 1.00; refractive index of the glass = 1.52.] [3]

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(ii) Calculate the angle *y*. [1]

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(iii) Show that light does not refract into the air at point **P**. [2]

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(iv) (I) The light changes its direction of travel at point **P**. What is the full name for the process involved? [1]

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(II) How does the size of angle *z* compare with the size of angle *y*? [1]

....

(b) (i) A glass fibre used for the transmission of data consists of a central glass *core* with a *cladding* of glass of lower refractive index. Suggest one advantage of having a glass cladding rather than simply an air surround. [1]

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(ii) What can be said about the diameter of a *monomode fibre*? [2]

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(iii) Why is such a fibre called *monomode*? [1]

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Examiner only

4. *(a)* (i) What is the *photoelectric effect?* [2]

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(ii) Give an account of the photoelectric effect in terms of photons, electrons and energy, explaining how it leads to *Einstein's photoelectric equation.* [4]

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(b) (i) A zinc surface of work function 4.97×10^{-19} J is irradiated with two frequencies of electromagnetic radiation in turn. For each frequency, show whether or not electrons are emitted from the surface, and if they are emitted, calculate their maximum kinetic energy.

(I) 7.99×10^{14} Hz [2]

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(II) 6.74×10^{14} Hz [1]

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(ii) What would be the maximum kinetic energy of the electrons emitted if the surface were irradiated with both frequencies at once? Explain your reasoning. [2]

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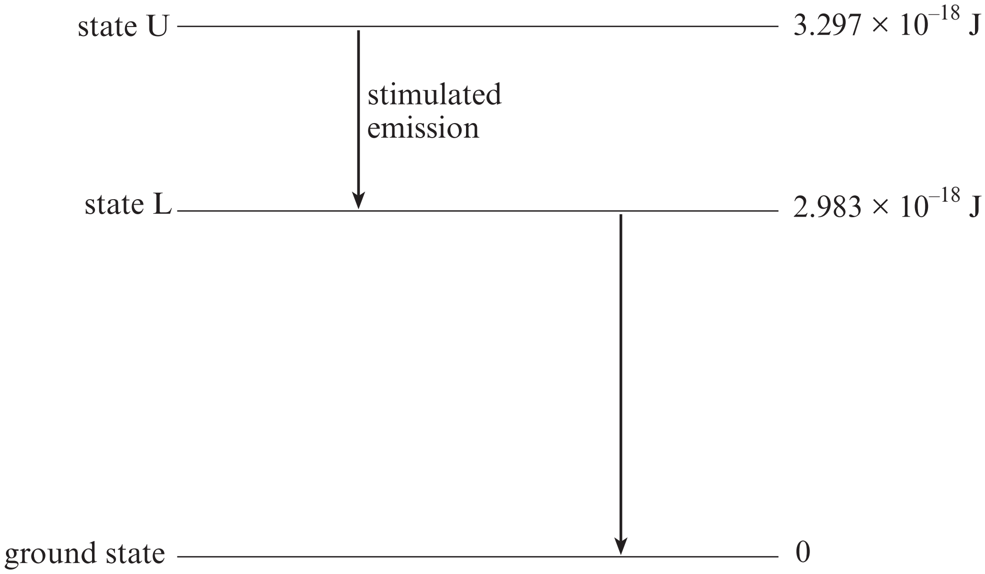
1322 01 07

Examiner only

5. In the helium-neon laser, excited helium atoms collide with neon atoms and transfer energy to them. This raises neon atoms from the ground state to the excited *metastable* state, U (see diagram).



Photons are emitted by stimulated emission involving an electron transition between state U and state L.

(a) (i) Calculate the fraction

$$\frac{\text{photon energy}}{\text{energy used to excite atom to level U}} .$$ [2]

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(ii) Calculate the wavelength of the light emitted. [2]

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(b) (i) What causes a stimulated emission event to occur? [2]

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(ii) Describe carefully, in terms of photons, the outcome of such an event. [2]

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(iii) An electron stays in level L for only a very short time, spontaneously dropping to the ground state. Explain why this feature is important to the operation of a laser. [2]

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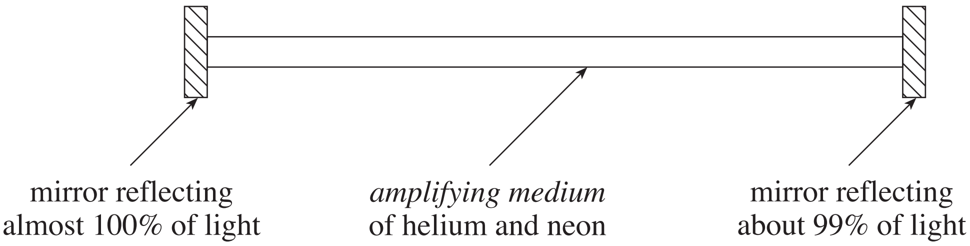
(iv) The mixture of helium and neon is contained in a long cavity with mirrors, as shown in the simplified diagram.



How does this cavity design promote laser operation? [2]

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