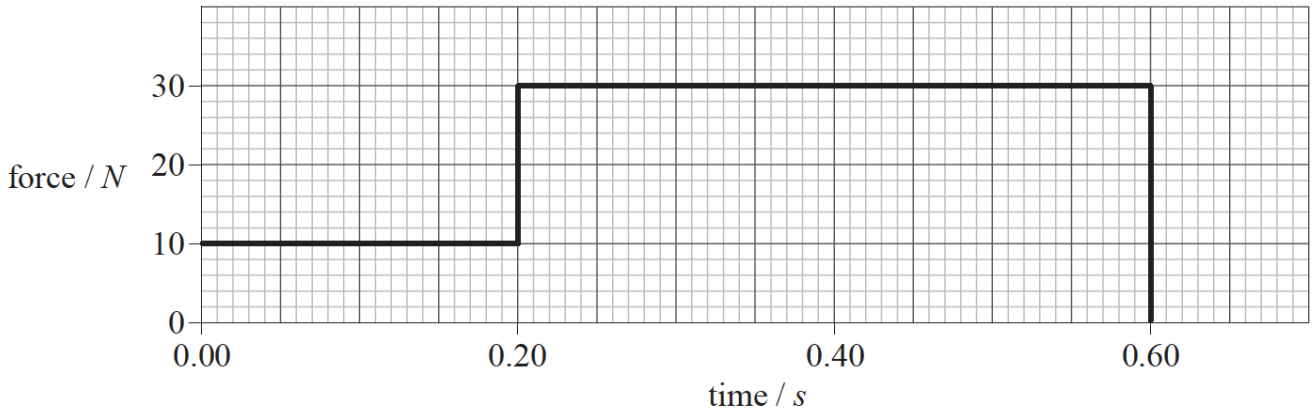
Physics (Units 2, 3, 4 and 6) - SL and HL *[53 marks]*

1. The graph shows how an external force applied to an object of mass 2.0 kg varies with time. The object is initially at rest. *[1 mark]*



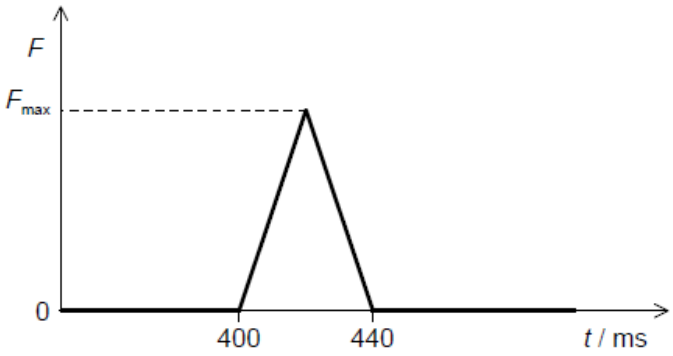
What is the speed of the object after 0.60 s?

A. 7.0 ms^{-1}
B. 14 ms^{-1}
C. 18 ms^{-1}
D. 28 ms^{-1}

2. An ice-hockey puck is slid along ice in a straight line. The puck travels at a steady speed of 20 ms^{-1} and experiences no frictional force. How far does the puck travel in 2.5 s? *[1 mark]*

A. 5 m
B. 8 m
C. 25 m
D. 50 m

3. A ball of mass 0.2 kg strikes a force sensor and sticks to it. Just before impact the ball is travelling horizontally at a speed of 4.0 m s^{-1}. The graph shows the variation with time t of the force F recorded by the sensor. *[1 mark]*



What is F_{max}?

A. 2 N

B. 4 N

C. 20 N

D. 40 N

4. A metal sphere is at rest on a bench. According to Newton's third law of motion, what is a possible action-reaction pair for this situation? *[1 mark]*

	Action	Reaction
A.	downwards gravitational force of Earth on the sphere	upwards gravitational force of the sphere on Earth
B.	upwards gravitational force of Earth on the sphere	downwards gravitational force of the sphere on Earth
C.	upwards electrostatic force acting on the sphere due to the atoms in the bench surface	upwards gravitational force of the sphere on Earth
D.	upwards electrostatic force acting on the sphere due to the atoms in the bench surface	downwards gravitational force of the sphere on Earth

5. A block of iron of mass 10 kg and temperature 10°C is brought into contact with a block of iron of mass 20 kg and temperature 70°C. No energy transfer takes place except between the two blocks. What will be the final temperature of both blocks? *[1 mark]*

A. 30°C
B. 40°C
C. 50°C
D. 60°C

6. The molar mass of magnesium is 24g. 12g of magnesium contains the same number of particles as *[1 mark]*

A. 6 g of carbon-12.

B. 12 g of carbon-12.

C. 24 g of carbon-12.

D. 6.02×10^{23} g of carbon-12.

7. The gravitational field strength at the surface of a certain planet is *g*. Which of the following is the gravitational field strength at the surface of a planet with twice the radius and twice the mass? *[1 mark]*

A. $\frac{g}{2}$

B. g

C. $2g$

D. $4g$

8. What is the acceleration of an object rotating with constant speed *v* in a circle of radius *r*? *[1 mark]*

A. Zero

B. $\frac{v^2}{r}$ towards the centre of the circle

C. $\frac{v^2}{r}$ away from the centre of the circle

D. $\frac{v^2}{r}$ along a tangent to the circle

9. A spacecraft travels away from Earth in a straight line with its motors shut down. At one instant the speed of the spacecraft is 5.4 km s^{-1}. After a time of 600 s, the speed is 5.1 km s^{-1}. The average gravitational field strength acting on the spacecraft during this time interval is *[1 mark]*

1. 5.0×10^{-4} N kg^{-1}
2. 3.0×10^{-2} N kg^{-1}
3. 5.0×10^{-1} N kg^{-1}
4. 30 N kg^{-1}

10. The motion of an object is described by the equation *[1 mark]*

acceleration $\propto -$ displacement.

What is the direction of the acceleration relative to that of the displacement and what is the displacement when the speed is a maximum?

	Direction of acceleration relative to displacement	Displacement when speed is a maximum
A.	same	max
B.	same	zero
C.	opposite	max
D.	opposite	zero

11. Two sound waves from a point source on the ground travel through the ground to a detector. The speed of one wave is 7.5 km s^{-1}, the speed of the other wave is 5.0 km s^{-1}. The waves arrive at the detector 15 s apart. What is the distance from the point source to the detector? *[1 mark]*

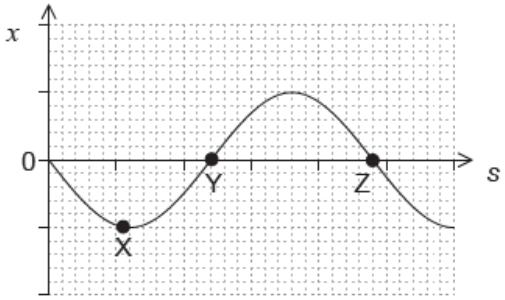
A. 38 km

B. 45 km

C. 113 km

D. 225 km

12. The graph shows the variation with position *s* of the displacement *x* of a wave undergoing simple harmonic motion (SHM). *[1 mark]*



What is the magnitude of the velocity at the displacements X, Y and Z?

	X	Y	Z
A.	maximum	zero	maximum
B.	zero	maximum	maximum
C.	maximum	maximum	zero
D.	zero	maximum	zero

13. A pair of slits in a double slit experiment are illuminated with monochromatic light of wavelength 480 nm. The slits are separated by 1.0 mm. What is the separation of the fringes when observed at a distance of 2.0 m from the slits? *[1 mark]*

A. 2.4×10^{-4} mm

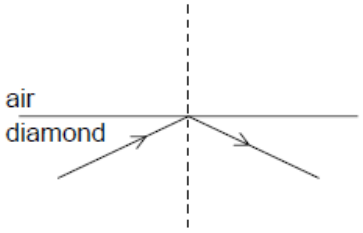
B. 9.6×10^{-4} mm

C. 2.4×10^{-1} mm

D. 9.6×10^{-1} mm

14. A light ray is incident on an air–diamond boundary. The refractive index of diamond is greater than 1. Which diagram shows the correct path of the light ray? *[1 mark]*

A.



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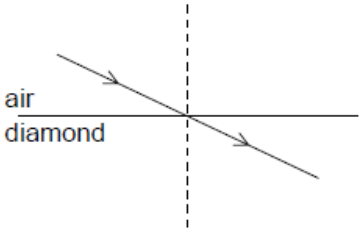

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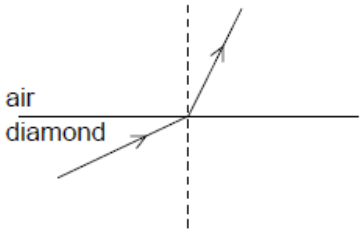
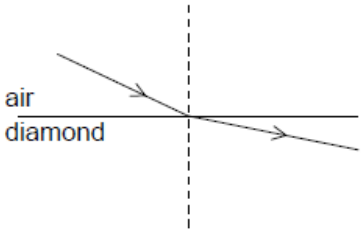
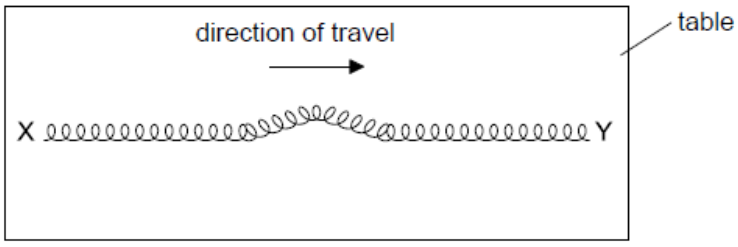


D.



15. A spring XY lies on a frictionless table with the end Y free. *[1 mark]*



A horizontal pulse travels along the spring from X to Y. What happens when the pulse reaches Y?

A. The pulse will be reflected towards X and inverted.
B. The pulse will be reflected towards X and not be inverted.
C. Y will move and the pulse will disappear.
D. Y will not move and the pulse will disappear.

16. Electromagnetic waves *[1 mark]*

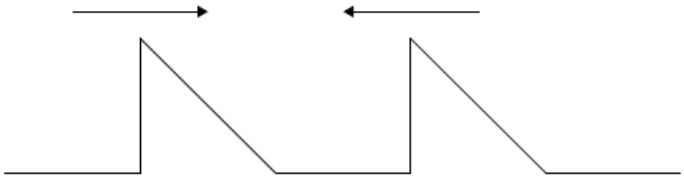
A. always obey an inverse square law.

B. are made up of electric and magnetic fields of constant amplitude.

C. always travel at the same speed in a vacuum.

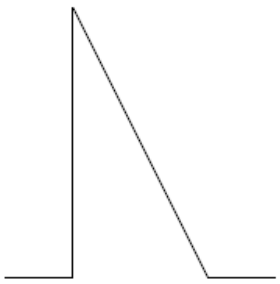
D. are always polarized.

17. Two pulses are travelling towards each other. *[1 mark]*



What is a possible pulse shape when the pulses overlap?

A.



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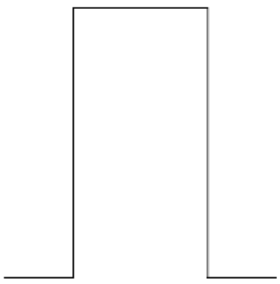
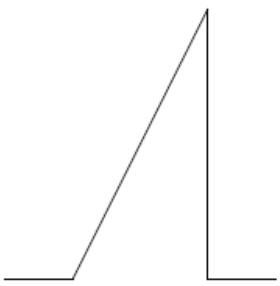


C.

D.



18. A pipe of length *L* has two open ends. Another pipe of length *L´* has one open end and one closed end. *[1 mark]*

The frequency of the first harmonic of both pipes is the same. What is $\frac{L'}{L}$?

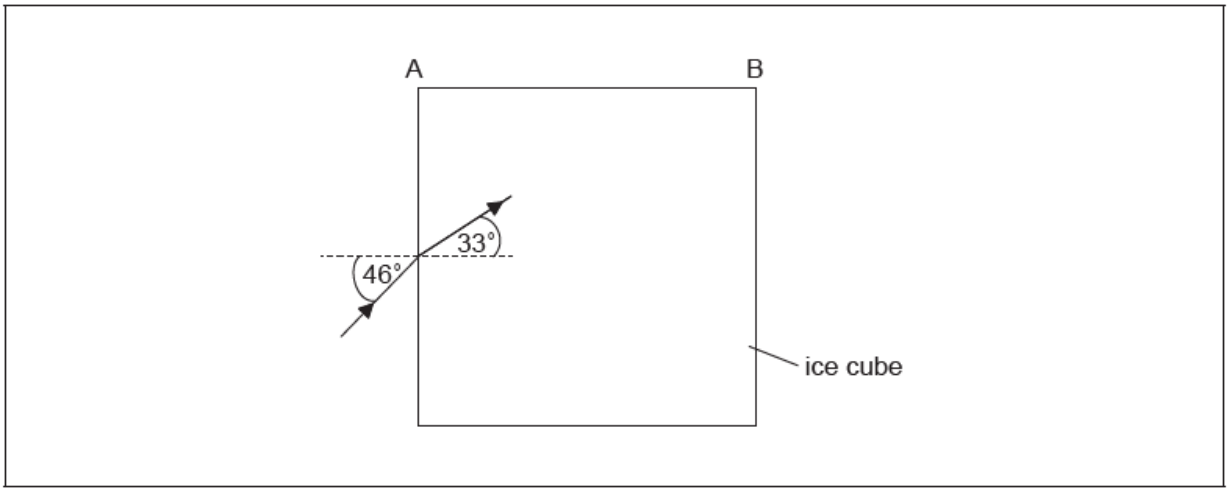
A. 2

B. $\frac{3}{2}$

C. 1

D. $\frac{1}{2}$

A large cube is formed from ice. A light ray is incident from a vacuum at an angle of 46° to the normal on one surface of the cube. The light ray is parallel to the plane of one of the sides of the cube. The angle of refraction inside the cube is 33°.



19a. Calculate the speed of light inside the ice cube. *[2 marks]*

19b. Show that no light emerges from side AB. *[3 marks]*

19c. Sketch, on the diagram, the subsequent path of the light ray. *[2 marks]*

Each side of the ice cube is 0.75 m in length. The initial temperature of the ice cube is –20 °C.

19d. Determine the energy required to melt all of the ice from –20 °C to water at a temperature of 0 °C. *[4 marks]*

Specific latent heat of fusion of ice = 330 kJ kg^{-1}
Specific heat capacity of ice = 2.1 kJ kg^{-1} k^{-1}
Density of ice = 920 kg m^{-3}

19e. Outline the difference between the molecular structure of a solid and a liquid. *[1 mark]*

This question is in **two** parts. **Part 1** is about ideal gases and specific heat capacity. **Part 2** is about simple harmonic motion and waves.

Part 1 Ideal gases and specific heat capacity

20a. State **two** assumptions of the kinetic model of an ideal gas. *[2 marks]*

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20b. Argon behaves as an ideal gas for a large range of temperatures and pressures. One mole of argon is confined in a cylinder by a freely moving piston. *[4 marks]*

(i) Define what is meant by the term *one mole of argon*.

(ii) The temperature of the argon is 300 K. The piston is fixed and the argon is heated at constant volume such that its internal energy increases by 620 J. The temperature of the argon is now 350 K.

Determine the specific heat capacity of argon in J kg^{-1} K^{-1} under the condition of constant volume. (The molecular weight of argon is 40)

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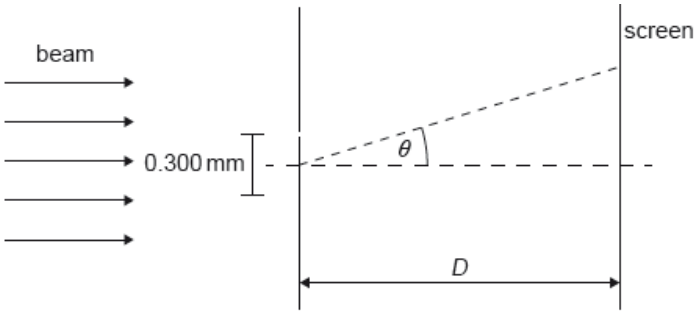
A beam of coherent monochromatic light from a distant galaxy is used in an optics experiment on Earth.

The beam is incident normally on a double slit. The distance between the slits is 0.300 mm. A screen is at a distance D from the slits. The diffraction angle θ is labelled.



21a. A series of dark and bright fringes appears on the screen. Explain how a dark fringe is formed. *[3 marks]*

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21b. The wavelength of the beam as observed on Earth is 633.0 nm. The separation between a dark and a bright fringe on the screen is 4.50 mm. Calculate D. *[2 marks]*

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The air between the slits and the screen is replaced with water. The refractive index of water is 1.33.

21c. Calculate the wavelength of the light in water. *[1 mark]*

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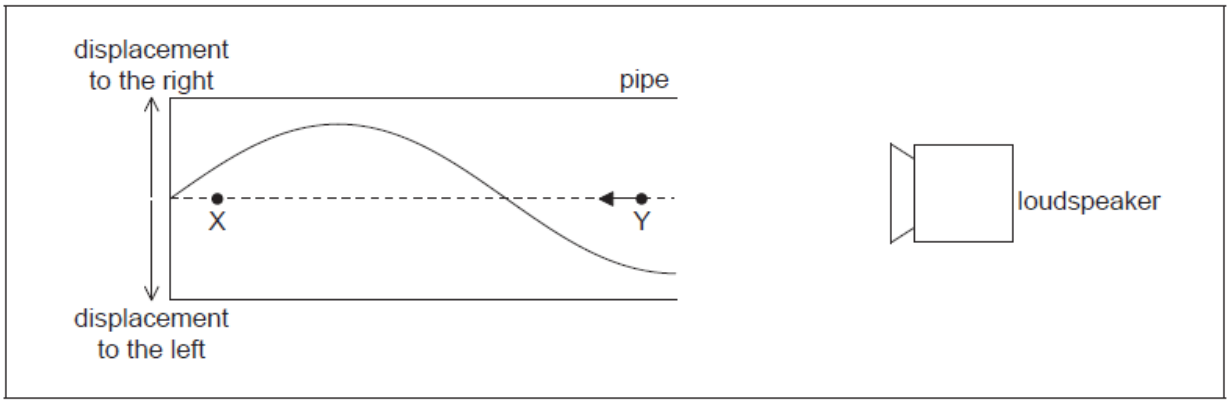
A loudspeaker emits sound towards the open end of a pipe. The other end is closed. A standing wave is formed in the pipe. The diagram represents the displacement of molecules of air in the pipe at an instant of time.



22a. Outline how the standing wave is formed. *[1 mark]*

X and Y represent the equilibrium positions of two air molecules in the pipe. The arrow represents the velocity of the molecule at Y.

22b. Draw an arrow on the diagram to represent the direction of motion of the molecule at X. *[1 mark]*

22c. Label a position N that is a node of the standing wave. *[1 mark]*

22d. The speed of sound is 340 m s^{-1} and the length of the pipe is 0.30 m. Calculate, in Hz, the frequency of the sound. *[2 marks]*

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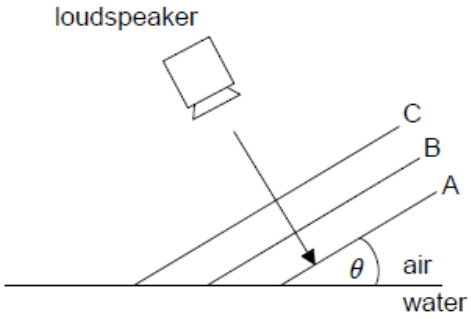
The loudspeaker in (a) now emits sound towards an air–water boundary. A, B and C are parallel wavefronts emitted by the loudspeaker. The parts of wavefronts A and B in water are not shown. Wavefront C has not yet entered the water.



22e. The speed of sound in air is 340 m s^{-1} and in water it is 1500 m s^{-1}. *[2 marks]*

The wavefronts make an angle θ with the surface of the water. Determine the maximum angle, θ_{max}, at which the sound can enter water. Give your answer to the correct number of significant figures.

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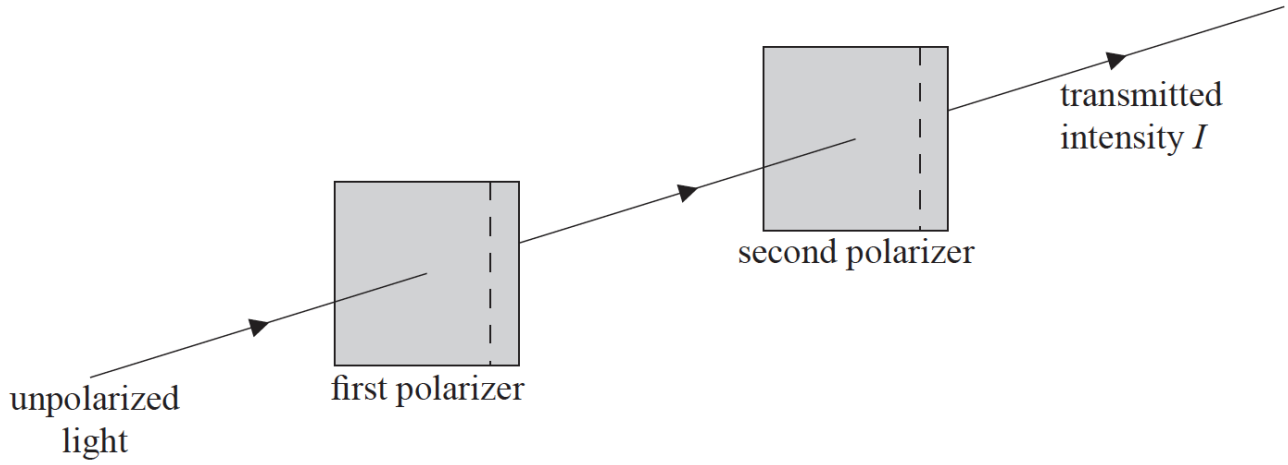
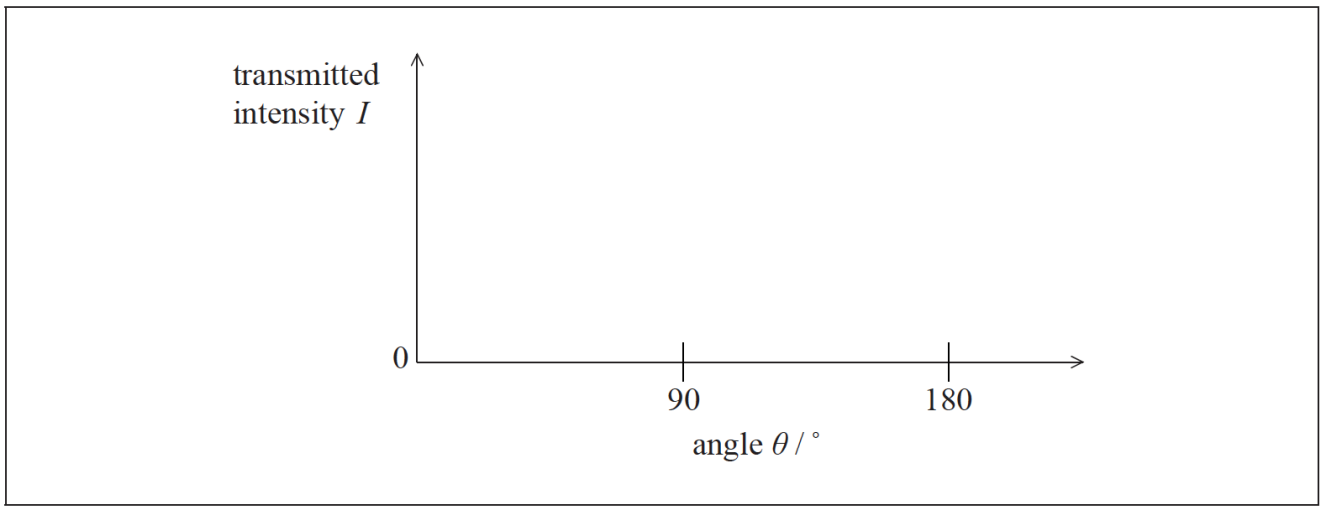
22f. Draw lines on the diagram to complete wavefronts A and B in water for $\theta < \theta_{max}$. *[2 marks]*

This question is about polarization.

Unpolarized light is directed towards two polarizers. The dashed lines represent the transmission axes of the polarizers. The angle θ between the transmission axes of the polarizers is initially 0º.



23. On the axes below, sketch a graph to show how the intensity I of the light emerging from the second polarizer varies with θ. *[2 marks]*



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