3 **(a)** Two coherent sources X and Y of microwaves of frequency 2.5×10^{10} Hz are of a distance of 0.18 m apart in a vacuum, as shown in Fig. 3.1.

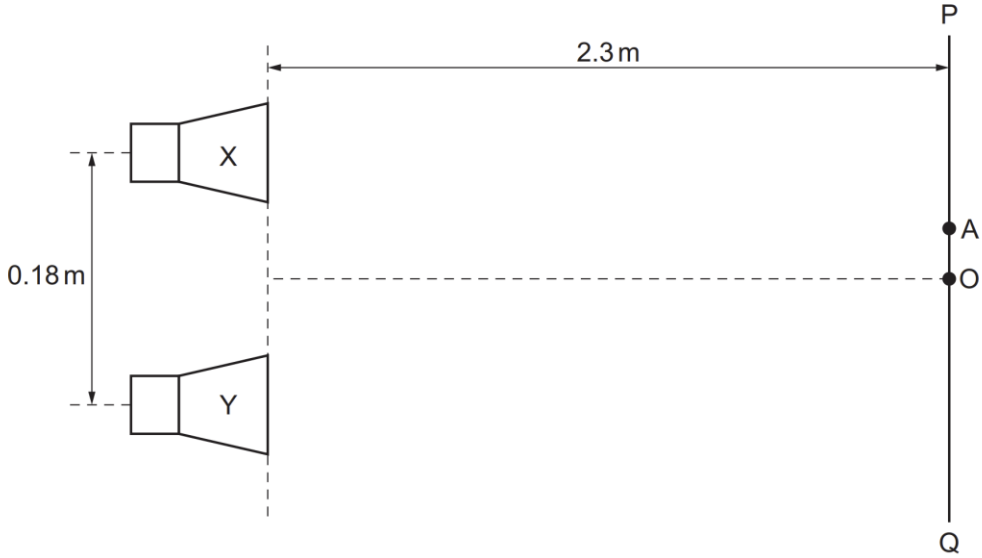

Fig. 3.1

There is a phase difference of **90°** between the waves emitted at the two sources.

A microwave detector moves along the line PQ, which is parallel to the line joining the two sources and 2.3 m away from it.

Point O is on the line PQ at a position that is equidistant from the two sources.
Point A is the position on the line PQ where the intensity of the microwaves is the greatest.

(i) Explain why the position of greatest intensity is **not** at point O.

....

....

....

.... [2]

(ii) On Fig. 3.1, draw a cross (X) to show the position of the point on line PQ where the intensity minimum that is closest to point O occurs. Label this point B. [1]

(iii) Use the formula for the double-slit interference of light to calculate the distance between adjacent intensity maxima on the line PQ.

distance = ... m [2]

(b) A pipe is open at one end and closed at the other end with a piston. The piston can slide freely and is at a distance of 45 cm from the open end of the pipe, as shown in Fig. 3.2.

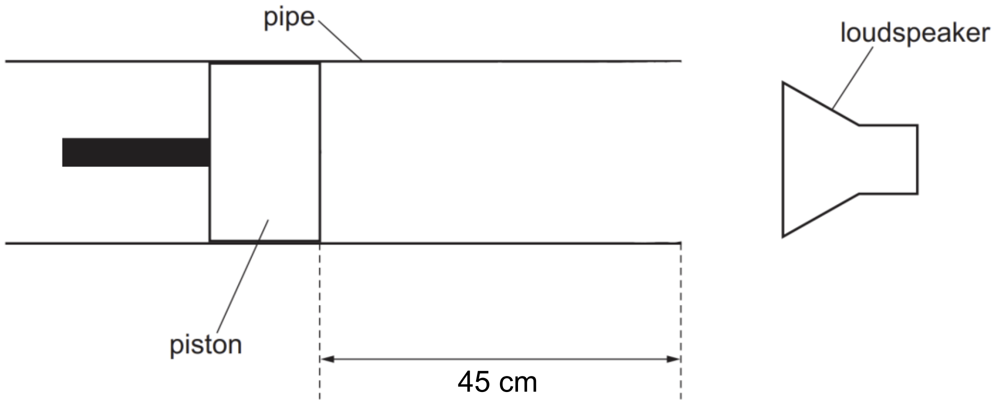

Fig. 3.2

A loudspeaker is positioned near the open end of the pipe. A loud sound is heard when the loudspeaker emits a sound wave of frequency 550 Hz. The speed of sound in the tube is measured to be 330 m s^{-1}.

(i) On Fig. 3.2, mark all the positions along the tube of

1. the displacement nodes (label these with the letter N),
2. the displacement antinodes (label these with the letter A). [2]

(ii) The frequency of the sound produced by the loudspeaker is gradually reduced.

Determine the lowest frequency at which a loud sound will be produced in the tube of length 45 cm.

frequency = ……………………. Hz [2]

(iii) The piston is moved to the left. The frequency of the sound wave emitted by the loudspeaker is then changed so that a stationary wave is formed with the same number of antinodes as in **(b)(ii)**.

State and explain the change that is made to the frequency of the sound wave.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(iv) An alternative, more reliable, method of measuring the speed of sound shows that 330 m s^{-1} is an underestimate. This underestimate cannot be attributed to the uncertainty in the measurement of either the frequency or the length of the pipe.

Suggest a reason that might have contributed to the underestimate.

.... [1]

(c) Two loudspeakers X and Y are connected to a signal generator and used to investigate interference. The loudspeakers emit sound waves of wavelength 0.16 m. The sound waves emitted from the two loudspeakers are in phase and have equal intensities.

The sound at point P is detected. Point P is 1.4 m from loudspeaker X and 1.8 m from loudspeaker Y, as shown in Fig. 3.3.

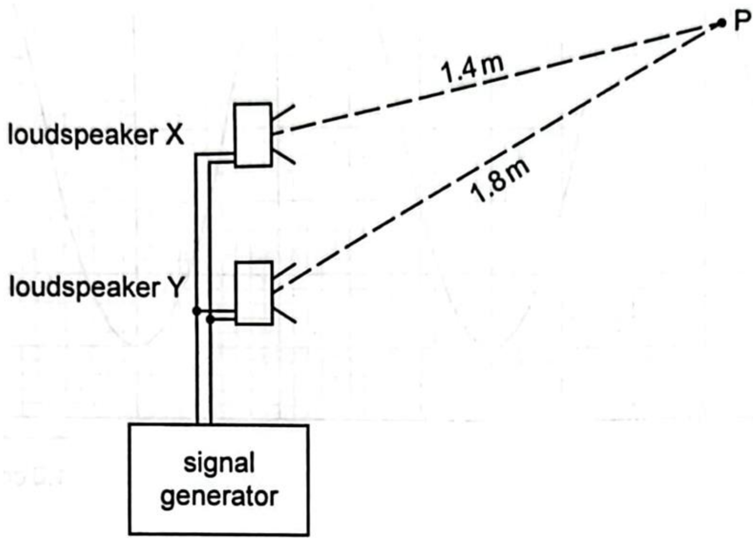

Fig. 3.3

The loudspeakers can be treated as point sources. The intensity at P of the sound from loudspeaker X is 4.5×10^{-6} W m^{-2}.

Show that the resultant intensity at point P is 2.2×10^{-7} W m^{-2}.

[3]