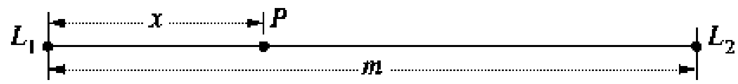
07	**10 b**	The noise level, N, at a distance d metres from a single sound source of loudness L is given by the formula $N = \dfrac{L}{d^2}$. Two sound sources, of loudness L_1 and L_2 are placed m metres apart.  The point P lies on the line between the sound sources and is x metres from the sound source with loudness L_1. (i) Write down a formula for the sum of the noise levels at P in terms of x. (ii) There is a point on the line between the sound sources where the sum of the noise levels is a minimum. Find an expression for x in terms of m, L_1 and L_2 if P is chosen to be this point.	**1** **4**

i. $N = \dfrac{L_1}{x^2} + \dfrac{L_2}{(m-x)^2}$

ii. $N = L_1x^{-2} + L_2(m-x)^{-2}$

$$\frac{dN}{dx} = -2L_1X^{-3} - 2L_2(m-x)^{-3}.-1$$

$$= \frac{-2L_1}{x^3} + \frac{2L_2}{(m-x)^3} = 0$$

$$\frac{2L_2}{(m-x)^3} = \frac{2L_1}{x^3}$$

$$\frac{(m-x)^3}{x^3} = \frac{2L_2}{2L_1}$$

$$\frac{m-x}{x} = \sqrt[3]{\frac{L_2}{L_1}}$$

$$\frac{m}{x} - 1 = \sqrt[3]{\frac{L_2}{L_1}}$$

$$\frac{m}{x} = 1 + \sqrt[3]{\frac{L_2}{L_1}}$$

$$m = x\left(1 + \sqrt[3]{\frac{L_2}{L_1}}\right)$$

$$x = m \div \left(1 + \sqrt[3]{\frac{L_2}{L_1}}\right)$$

Now, $\dfrac{dN}{dx} = -2L_1x^{-3} + 2L_2(m-x)^{-3}$

$$\frac{d^2N}{dx^2} = 6L_1x^{-4} - 6L_2(m-x)^{-4}.-1$$

$$= \frac{6L_1}{X^4} + \frac{6L_2}{(m-x)^4}, \text{ which is } > 0,$$

for all values of x.

As $\dfrac{d^2N}{dx^2} > 0$, then minimum when

$$x = m \div \left(1 + \sqrt[3]{\frac{L_2}{L_1}}\right).$$

* These solutions have been provided by *projectmaths* and are not supplied or endorsed by the Board of Studies

Board of Studies: Notes from the Marking Centre

(i) Successful candidates recognised the need to use L_1 and L_2 in the formula and that the formula required the sum of two terms. 'Formula for the sum' was interpreted by some candidates as requiring the 'sum of an arithmetic progression'. Care needs to be taken to ensure subscripts are not lost in working out, particularly at this stage in the paper where candidates may be rushing.

(ii) Typical responses included an attempt to differentiate the formula from (i). The most efficient method was to write the formula in terms of negative indices and use the function of a function rule. Many candidates attempted the function of a function rule but did not multiply by the coefficient of x. Giving the two terms a common denominator and applying the quotient rule inevitably led to errors and increased the difficulty of the question. If the correct derivative was found, successful candidates understood not to expand the cubic expressions but to take the cube root once the equation was manipulated.

Source: http://www.boardofstudies.nsw.edu.au/hsc_exams/