Q- When a pin of mass 0.120 g is dropped from a height of 0.80 m, 0.05% of its energy is converted into a sound pulse with a duration of 0.1 s.

(a) Estimate the range at which the dropped pin can be heard if the minimum audible intensity is 10^{-11} W/m^2.

The energy of the pin just before striking ground is given by loss in its potential energy which is given by

$\Delta U = mg\,h = (0.120*10^{-3}\ kg)*9.8*0.80 = 9.408*10^{-4}$ J

0.05% of this energy is converted to sound and hence sound energy of the pulse will be

$0.05*\Delta U/100 = 5*9.408*10^{-4}/100 = 4.704*10^{-7}$ J

Hence the power of the pulse is given by

$P = 4.704*10^{-7}/0.1 = 4.704*10^{-6}$ W

If the range of this pulse to be heard is r then we have

$$I = \frac{P}{4\pi r^2} = \frac{4.704*10^{-6}}{12.566*r^2} = 10^{-11}$$

Gives $r^2 = \dfrac{4.704*10^{-6}}{12.566*10^{-11}} = 3.743*10^4$

Or r = 193.5 m

(b) Your result in (a) is much too large in practice because of background noise. If you assume that the intensity must be at least 10^{-8} W/m^2 for the sound to be heard, estimate the range at which the dropped pin can be heard.

In this case If the range of this pulse to be heard is r_1 then we have

$$I = \frac{P}{4\pi r_1^2} = \frac{4.704*10^{-6}}{12.566*r^2} = 10^{-8}$$

Gives $r^2 = \dfrac{4.704*10^{-6}}{12.566*10^{-8}} = 37.43$

Or r = 6.12 m