In order to determine the unknown frequency (f) of a given tuning fork, you are provided with a sonometer and a single mass M as shown in figure. In the given sonometer, it is possible to change the tension of the wire by hanging the given mass at different slots of an arm of a lever which is pivoted at P. Slots are numbered from 1 to 5 as shown in the figure, and distances to the slots 1, 2, 3, 4 and 5 from P are 1.0, 2.0, 3.0, 4.0 and 5.0 cm, respectively. **Perpendicular distance from P to the wire is also 1.0 cm.** Assume that the elongation of the wire due to the mass is kept negligibly small.
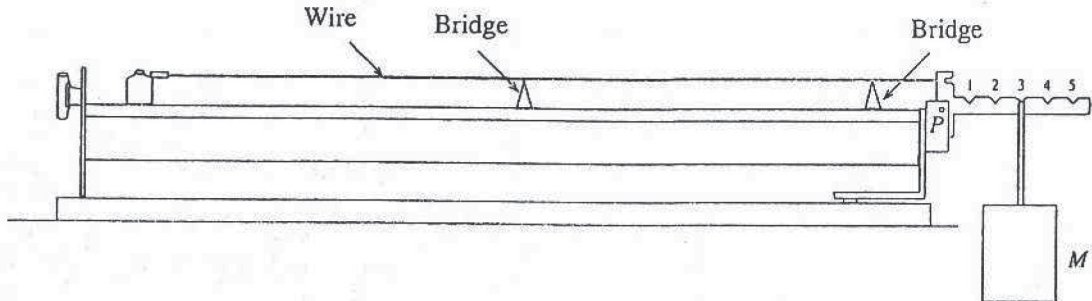
(a) How do you experimentally find the fundamental resonance length (l) of the sonometer wire that resonates with the given tuning fork?

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(b) Write down an expression for l in terms of f, tension of the wire (T), and mass per unit length of the wire (m).

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(c) The mass M is hung from each slot and corresponding value of l is measured. When the mass is hung from the nth slot (n = 1, 2, 3, 4, 5), the tension of the wire is given by $T = Mgn$. How do you obtain this relationship?

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(d) Obtain an expression for l^2 in terms of Mg, m, f and n.

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(e) The maximum tension that the sonometer wire can bear without producing a significant elongation is 54 N. What is the maximum value of M (in kg) which enables you to use all five slots for taking measurements?

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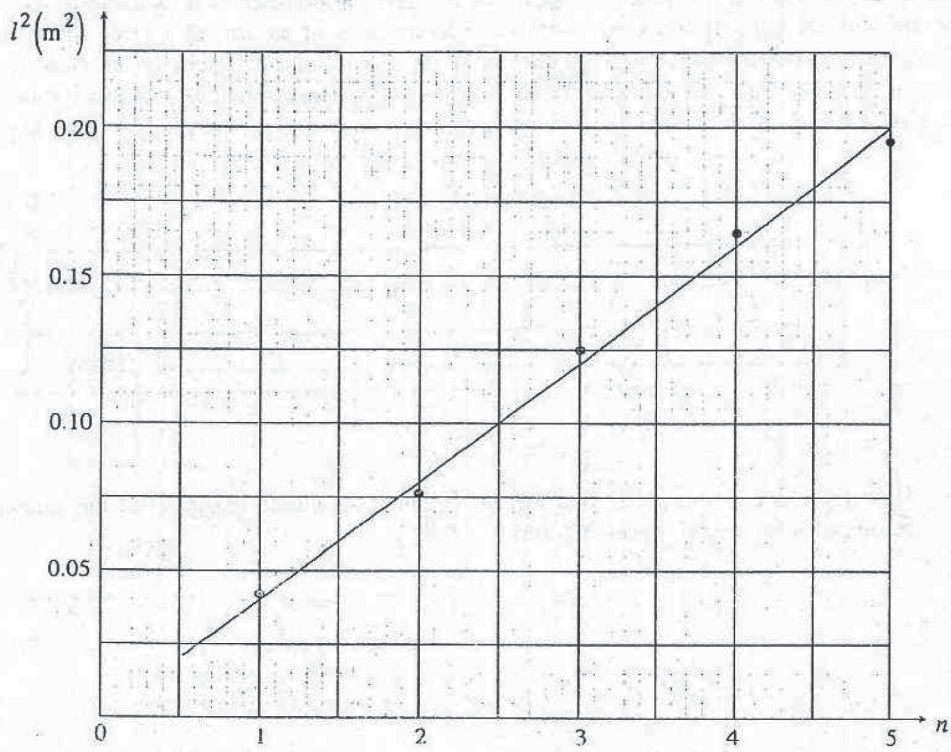
(f) You are provided with the density of the material of the sonometer wire. In order to determine the value of m, write down the measurement you have to make, together with the measuring instrument you use for that measurement.

(i) Measurement to be obtained : ....

(ii) Appropriate measuring instrument : ....

(g) A graph of l^2 *versus* n drawn in such an experiment is given below.

(i) Obtain the numerical value of the quantity required from the graph in order to determine the value of f.

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(ii) If $M = 0.5$ kg and $m = 2 \times 10^{-3}$ kg m^{-1}, calculate the value of f.

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