4 A tube closed at one end, has a constant area of cross section A. Some lead shots are placed in the tube so that the tube floats vertically in a liquid of density ρ. The total mass of the tube and its contents is M.

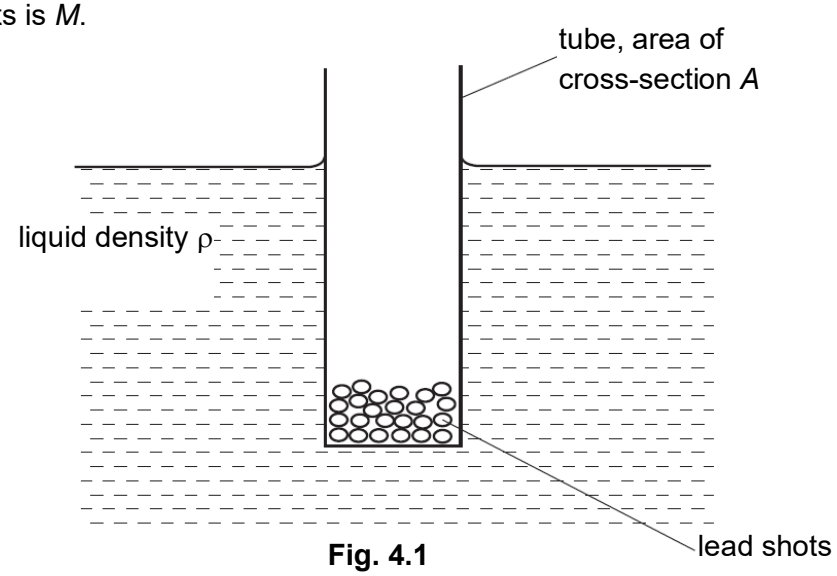

Fig. 4.1

(a) When the tube is given a small vertical displacement and then released, show that the acceleration a of the tube is related to its vertical displacement y by the expression

$$a = -\frac{A\rho g}{M} y.$$

[2]

(b) Fig. 4.2 shows the variation with time t of the vertical displacement y of the tube in another liquid.

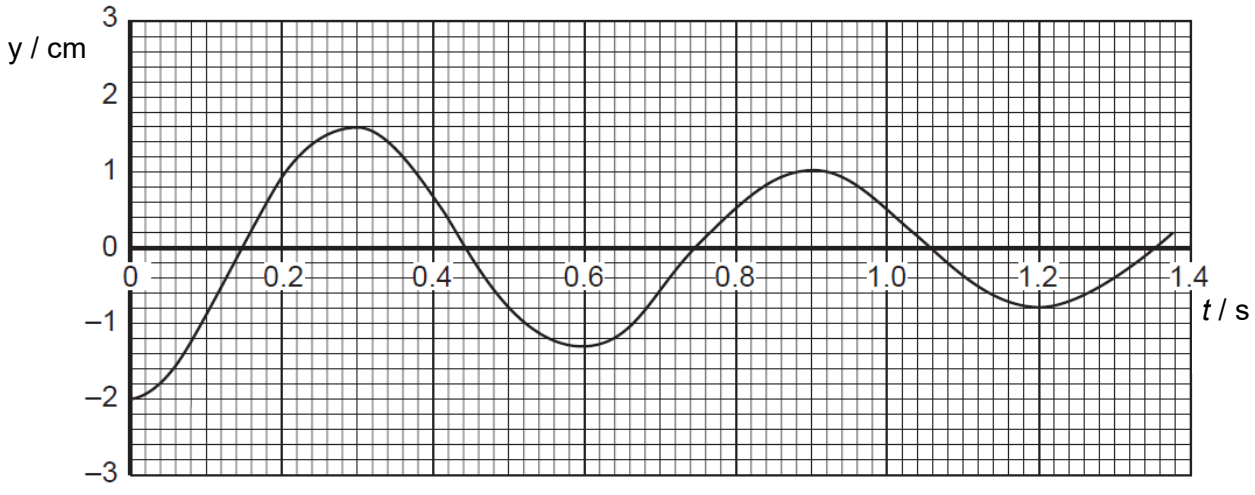

Fig. 4.2

(i) Determine the frequency f_0 of the oscillating tube.

f_0 = ... Hz [2]

(ii) The tube has an external diameter of 2.4 cm and is floating in a liquid of density 950 kg m^{-3}. Calculate the mass of the tube and its contents.

mass = ... kg [3]

(iii) More lead shots are added to the tube. State and explain the changes to the graph in Fig. 4.2.

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.....[1]

[Total: 8]