A proposed application of a transducer to measure volumetric flow in a pipe is shown schematically in Figure 1. A restriction is introduced into the pipe to produce a pressure difference ($p_1 > p_4$). The transducer is connected via two connecting pipes and the ensuing pressure difference in the transducer ($p_2 > p_3$) produces a deflection (x) of the transducer mass. This deflection is a measure of the volumetric flow rate (f). The movement of the transducer mass (M) is opposed by a spring (of spring constant K) and by viscous damping effects (characterised by the viscous damping coefficient B). It is assumed that the fluid in the connecting pipes behaves as a solid mass and that a linearised coefficient (C) describes the relationship between flow and pressure difference for the restriction.

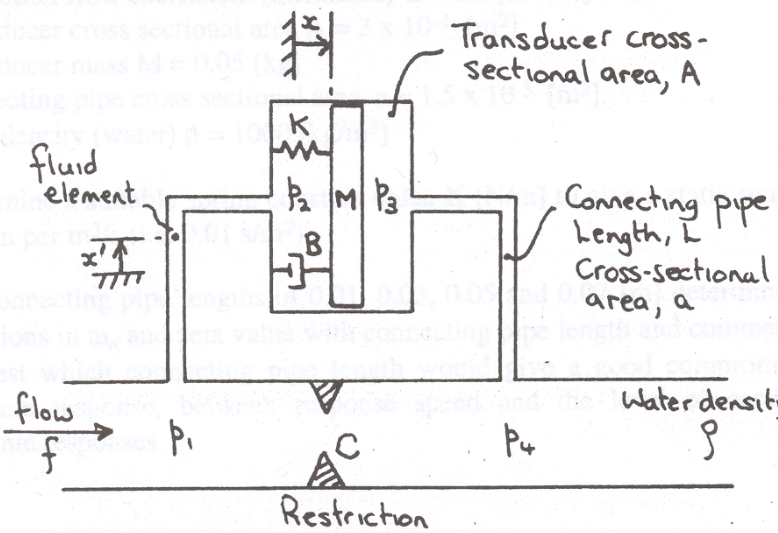

Figure 1

Use system dynamics techniques to show that the transfer function of the proposed measurement system is given by :

$$\frac{x}{f} = \frac{\frac{A}{CK}}{1 + \left(\frac{B}{K}\right)D + \left(\frac{M}{K} + \frac{2M_f}{K}\frac{A^2}{a^2}\right)D^2}$$

where D = D operator = d/dt

A = Cross sectional area of transducer

a = Cross sectional area of connecting pipe

M_f = Mass of fluid in one connecting pipe

and M_f = ρ.a.L where ρ = fluid density

L = length of connecting pipe.