3. (a) FIGURE 2 shows two cylindrical tanks interconnected with a pipe which has a valve that creates a constant resistance to flow of R_f when fully open. The height of liquid (of density ρ) in the first tank is h_{in} and the second tank h_{out}. The cross-sectional area of the first tank is A_{in} m^2 and the second tank A_{out} m^2.

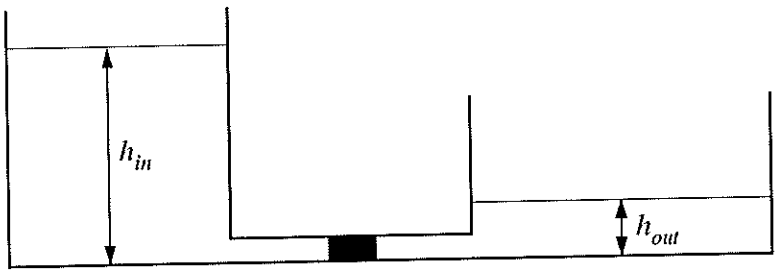

FIG. 2

The flow rate of liquid through the valve is given by

$$Q = \frac{1}{R_f}(p_{in} - p_{out})$$

where Q = flow rate in m^3 s^{-1}
p_{in} = pressure due to height of liquid in first tank (Pa)
p_{out} = pressure due to height of liquid in second tank (Pa)

Produce a mathematical model of the process to determine the change in height of fluid in the second tank when the valve is open.

(b) Determine the time constant for the system.