4.41) Water ($\rho = 1000\ kg/m^3$) is accelerated from rest in a horizontal pipe that is 80m long and 30 cm in diameter. If the acceleration rate (toward the downstream end) is $5\ m/s^2$, what is the pressure at the upstream end if pressure at the downstream end is 90 kPa gage?

KNOWN:

$L = 80\ m$
$D = 30\ cm$
$a_s = 5\ m/s^2$
$\rho = 1000\ kg/m^3$
$P_{downstream} = 90\ kPa$

UNKNOWN:

$P_{upstream} = ?$

GOVERNING EQN:

$$\frac{\partial P}{\partial s} = -\rho a_s$$

SOLUTION:

$$\frac{\partial P}{\partial s} = -\rho a_s$$

$$= -1000\ \frac{kg}{m^{\frac{3}{2}}}\left(\frac{5m}{s^2}\right) = -5000\ N/m^3$$

$$\frac{P_{down} - P_{up}}{\Delta S} = \frac{\partial P}{\partial s}$$

$$P_{up} = 90{,}000\ Pa + (5000\ N/m^3)(80\ m)$$

$$= 490{,}000\ Pa\ gage$$

$$\boxed{P_{upstream} = 490\ kPa\ gage}$$