Institute of Hydraulic and Water Resources Engineering, Vienna University of Technology

Coastal & Ocean Engineering

Tutorial Sheet 1 – Material derivatives

Material derivatives

1. By considering the temperature T of a particle of fluid at position $\mathbf{r}$ and time t and at time $t+\delta t$ at position $\mathbf{r}+\delta\mathbf{r}$, show that the apparent time rate of change of temperature of the particle is

$$\frac{DT}{Dt} = \frac{\partial T}{\partial t} + \mathbf{u}\cdot\nabla T.$$

2. Water flows steadily along a horizontal pipe which reduces uniformly in section from $20\,\mathrm{cm}$ diameter to $10\,\mathrm{cm}$ diameter in a distance of $1\,\mathrm{m}$. The volume flow rate is $0.02\,\mathrm{m^3\,s^{-1}}$ Obtain an expression for pipe diameter as a function of distance x from the beginning of the reducer, and obtain successively expressions for area, mean velocity and mean velocity gradient as functions of x. Hence or otherwise, calculate the acceleration of a fluid particle at the beginning of the reducer and at the end. (*Ans.:* $0.41\,\mathrm{m\,s^{-2}}$, $13\,\mathrm{m\,s^{-2}}$).