CFD problem

consider a fluid bounded by two parallel plates extended to infinity such that no end effects are encountered. The planar walls and the fluid are initially at rest. Now, the lower wall is suddenly accelerated in the x-direction, as illustrated in Figure 3-6. A spatial coordinate system is selected such that the lower wall includes the xz plane to which the y-axis is perpendicular. The spacing between two plates is denoted by h.

The Navier-Stokes equations for this problem may be expressed as

$$\frac{\partial u}{\partial t} = \nu \frac{\partial^2 u}{\partial y^2}$$

where ν is the kinematic viscosity of the fluid. It is required to compute the velocity profile $u = u(t, y)$. The initial and boundary conditions for this problem are stated as follows:

(a) Initial condition $\quad t = 0\,, \quad u = U_0 \quad \text{for} \quad y = 0$

$\qquad u = 0 \quad \text{for} \quad 0 < y \leq h$

(b) Boundary conditions $\quad t \geq 0\,, \quad u = U_0 \quad \text{for} \quad y = 0$

$\qquad u = 0 \quad \text{for} \quad y = h$

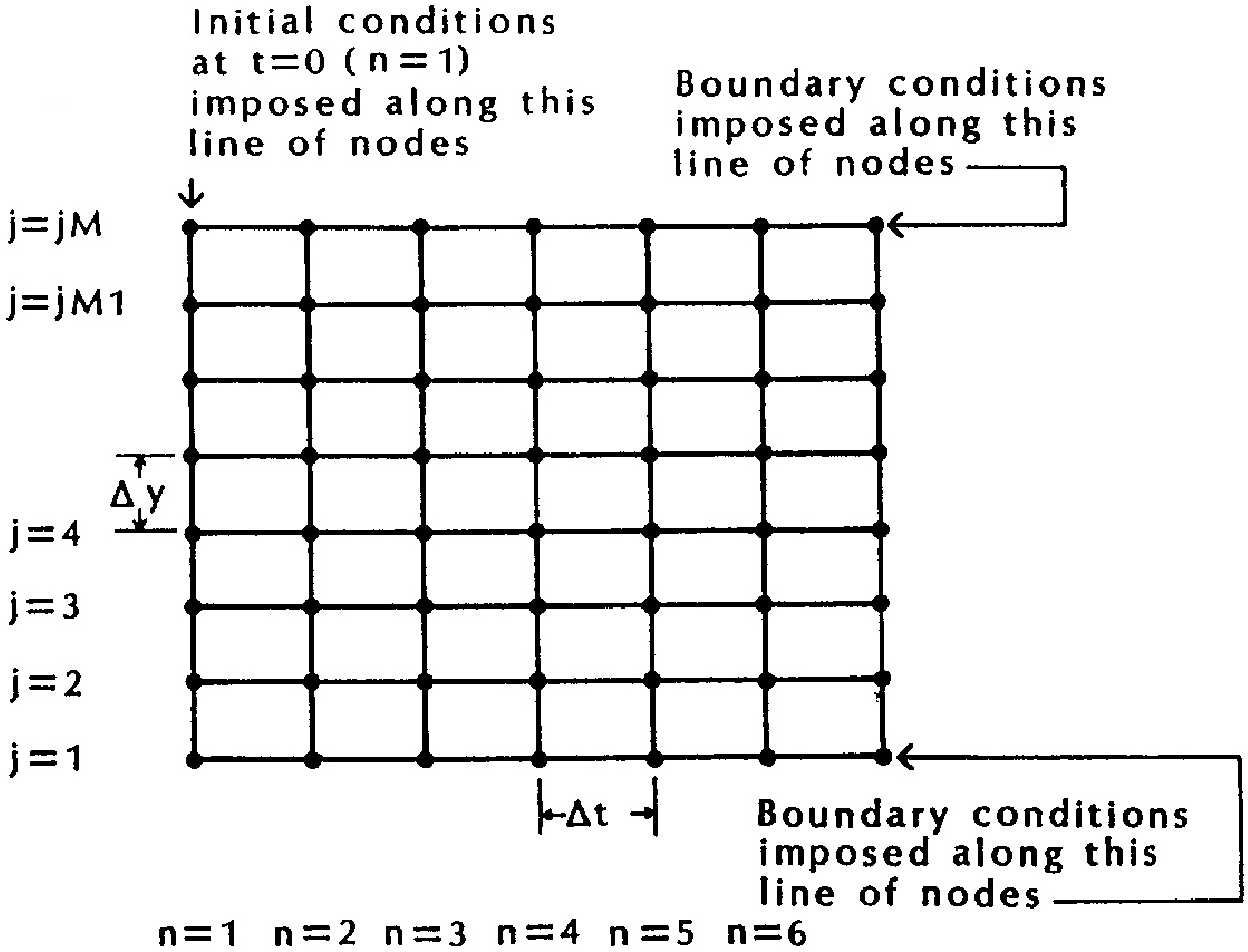
The fluid is oil with a kinematic viscosity of 0.000217 m^2/s, and the spacing between plates is 40 mm. The velocity of the lower wall is specified as $U_0 = 40$ m/s. A solution for the velocity is to be obtained up to 1.08 seconds.

A grid system with $\Delta y = 0.001$ m and various values of time steps is to be used to investigate the numerical schemes and the effect of time step on stability and accuracy. By selecting $j = 1$ at the lower surface and spatial step size of 0.001, j at the upper surface would be 41. JM and NM will be used to denote the number of steps in the y-direction and time, respectively. Note that $n = 1$ is used for $t = 0$, i.e., initial condition. The grid system is illustrated in Figure 3-6.

An attempt is made to solve the stated problem subject to the imposed initial and boundary conditions by the following:

The FTCS explicit method with $\Delta t = 0.002$, $NM = 541$

CFD problem



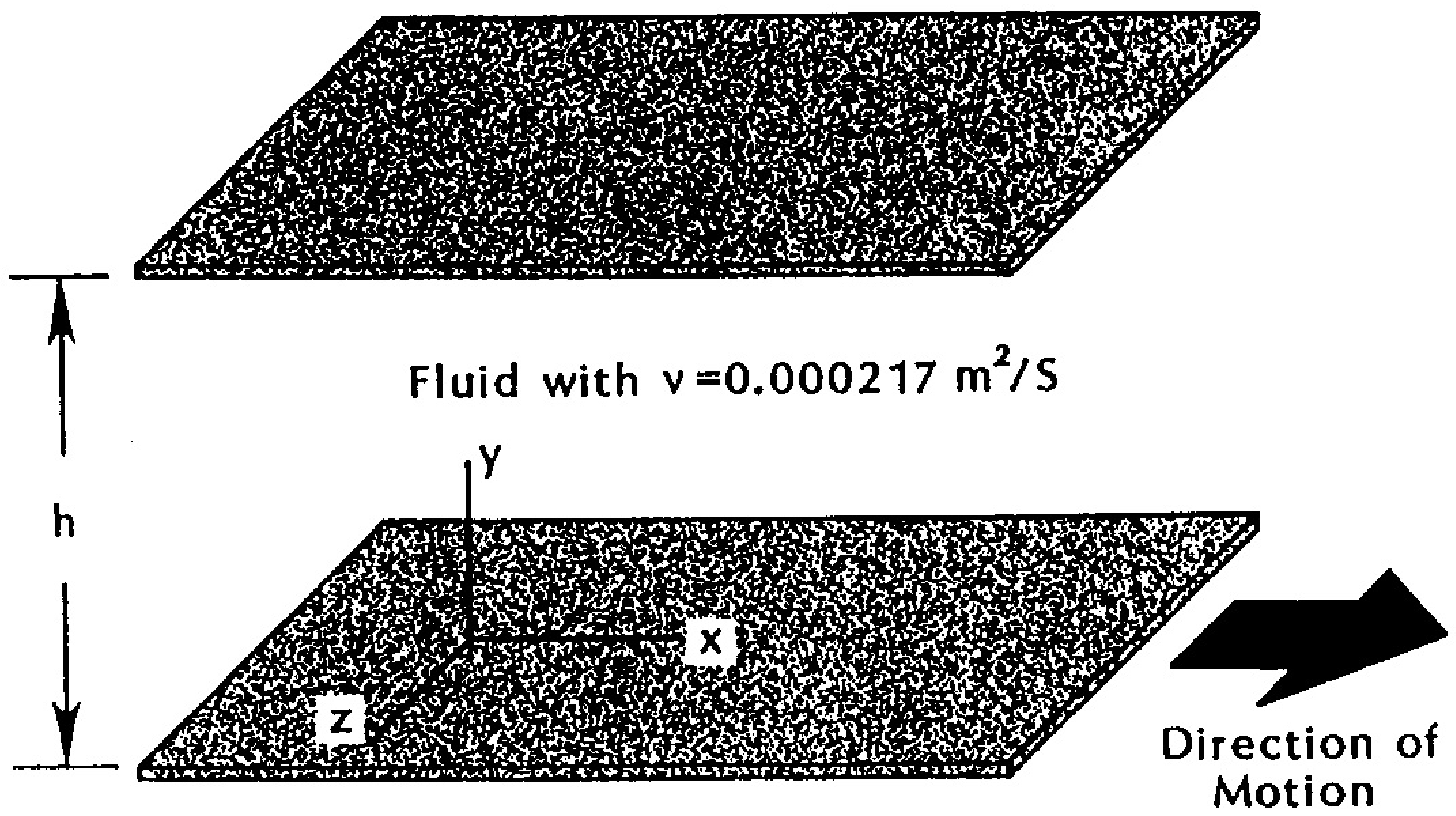


Figure — Physical space and the computational grid system for a suddenly accelerated plane wall.