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DEPARTMENT OF AEROSPACE ENGINEERING

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Course	:	**19ASB304 - Computational Fluid Dynamics for Aerospace Application**			

UNIT II – DISCRETIZATION

Concept of Numerical Dissipation

Definition of Numerical Dissipation

As mentioned above, the question of numerical dissipation arises for advection-dominated problems. Numerical dissipation is therefore defined by the advection (wave) equation:

$$\frac{\partial u}{\partial t} + c\frac{\partial u}{\partial x} = 0$$

9 This equation describes the transport of the quantity u with speed c. Its general solution is $u = f$
($x-ct$). A particular solution is the periodical solution.

$$u = e^{ik(x-ct)} = e^{ikx}e^{-i\omega t} \qquad \text{with } \omega = kc$$

Which represents the unattenuated propagation of a wave of length $2\pi/k$ with speed c.

Let us compute the amplification ion factor $u(x, t+\Delta t)/u(x, t)$ for the exact solution. We find

$$\frac{u(x,t+\Delta t)}{u(x,t)} = e^{-i\omega\Delta t} = e^{-ikc\Delta t} = e^{-i\eta\nu}$$

with

$$\nu = \frac{c\Delta t}{\Delta x} \quad \text{CFL number}$$
$$\eta = k\Delta x \quad \text{dimensionless wave number}$$

A numerical solution will yield.

$$\frac{u_i^{n+1}}{u_i^n} = g(\eta, \nu)$$

When one wishes to accurately follow a true unsteady phenomenon, one desires to have $g(\eta,\nu)$ as close as possible to $e^{-i\eta\nu}$. For stability, one must have $|g(\eta,\nu)| \leq 1$ for all η. The difference between $|g(\eta,\nu)|$ and 1 is called *dissipation* or else *dissipative error,* and the difference between $\arg(g(\eta,\nu))$ and $-\eta\nu$ is called *dispersion* or *dispersive error*.