

# Numerical solution of a simple complex differential equation

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## Introduction

A simple complex differential equation is solved numerically using the finite volume method. Time discretization is fully implicit.

## Model equations

The following complex differential equation is solved:

$$ih \frac{d\psi}{dt} = \psi \quad (1)$$

Where  $i$  is the imaginary number,  $h$  a constant,  $\psi$  the dependent variable and  $t$  time.

## Discretization

Since the dependent variable  $\psi$  depends only on time  $t$  a single node can be used to represent the domain of  $\psi$ . The discrete form of equation (1) for this single node is:

$$\psi_p = \frac{\psi_{p-1} \left( \frac{h^2}{\Delta t} - ih \right)}{\Delta t \left( 1 + \frac{h^2}{\Delta t^2} \right)} \quad (2)$$

Where the subscript  $p$  denotes the timestep.

## Verification

In order to verify that the computation is proceeding correctly the numerical solution to equation (1) is compared with the analytical solution to equation (1):

$$\psi = \psi_0 (\cos(t/h) - i \sin(t/h)) \quad (3)$$

Where the subscript 0 of  $\psi_0$  is the initial value of  $\psi$ . A comparison between numerical and analytical solutions is given in table [1]. Analysis shows that the discrepancy between numerical and analytical results is small.

Table 1: Numerical and analytical data.

$t$	analytical solution (real)	numerical solution (real)
0.1	1.09484	1.09484
0.2	1.17874	1.17874
0.3	1.25086	1.25086
0.5	1.35701	1.35701
1.0	1.38177	1.38176
2.0	0.49315	0.49311
4.0	-1.41045	-1.41033