

A Document for Testing DocOnce

Hans Petter Langtangen^{1,2} (hpl@simula.no)

Kaare Dump³

A. Dummy Author

I. S. Overworked and Outburned^{4,5,6,7}

J. Doe (j_doe@cyberspace.com)

¹Center for Biomedical Computing, Simula Research Laboratory

²Department of Informatics, University of Oslo

³Segfault, Cyberspace

⁴Inst1

⁵Inst2, Somewhere

⁶Third Inst, Elsewhere

⁷Fourth Inst

Mar 2, 2021

Contents

1	Section 1	2
1.1	Subsection 1	3
1.2	Subsection 2: Testing figures	11
1.3	The θ parameter (not ∇ ?)	13
1.4	Custom Environments	15
1.5	Tables	15
1.6	A test of verbatim words in heading with subscript a_i : my_file_v1 and my_file_v2	17
1.7	Just bold	17
1.8	<i>Just emphasize</i>	17
1.9	Just verbatim	17
1.10	Bold beginning	17
1.11	<i>Emphasize</i> beginning	17
1.12	Verbatim beginning	17
1.13	Maybe bold end	18
1.14	Maybe <i>emphasize end</i>	18

1.15	Maybe <code>verbatim end</code>	18
1.16	The middle has bold word	18
1.17	The middle has <i>emphasize</i> word	18
1.18	The middle has <code>verbatim</code> word	18
1.19	Bibliography test	19
1.20	User-defined environments	20
1.21	URLs	20
1.22	Test of Some L ^A T _E X Fixes	21
2	L^AT_EX Mathematics	21
3	Exercises	22
3.1	Not an exercise	23
4	Here goes another section	28
5	More Exercises	28
	References	28
A	Just for testing; part I	30
A.1	A subsection within an appendix	30
B	Just for testing; part II	30
B.1	Appendix: Testing identical titles	30
B.2	Appendix: Testing identical titles	30
B.3	Appendix: Testing identical titles	30
B.4	Appendix: Testing identical titles	31
B.5	Appendix: Testing inline comments	33
B.6	Appendix: Testing headings ending with <code>verbatim inline</code>	33
	Index	35

The format of this document is plain, homemade PDF^LA_TE_X (from DocOnce).

Abstract

This is a document with many test constructions for doconce syntax. It was used heavily for the development and kept for testing numerous constructions, also special and less common cases.

And exactly for test purposes we have an extra line here, which is part of the abstract.

1 Section 1

Here is a nested list:

- item1
- item2
- item3 which continues on the next line to test that feature
- and a sublist
 - with indented subitem1
 - and a subitem2
- and perhaps an ordered sublist
 1. first item
 2. second item, continuing on a new line

Here is a list with paragraph heading.

- item1
- item2

Here is a list with subsubsection heading.

- item1
- item2

Here are two lines that make up a block quote for testing *emphasized words* and **boldface words**, also with hypens: *pre*-fix, post-*fix*, **pre**-fix, post-**fix**.

Here are two references. Equation (10) is fine. Eq. (10) too. Even Equation (10) without the tilde.

1.1 Subsection 1

More text, with a reference back to Section 1 on page 2 and 1.1, and further to the sections 1.1 and 1.21 on page 20, which encourages you to do the tasks in the Exercises 2 on page 22 and 9 on page 28. Appendices A on page 30 and B on page 30 are also nice elements.

Test Section reference at beginning of line and after a sentence. Section 1.1 is fine. Section 1.21 on page 20 too.

Computer code. Let's do some copying from files too. First from subroutine up to the very end,

```

subroutine test()
integer i
real*8 r
r = 0
do i = 1, i
    r = r + i
end do
return
C  END1

program testme
call test()
return

```

and then just the subroutine,

```

subroutine test()
integer i
real*8 r
r = 0
do i = 1, i
    r = r + i
end do
return

```

and finally the complete file with a plain text verbatim environment (`envir=ccq`):

```

1  C      a comment

      subroutine test()
4      integer i
      real*8 r
      r = 0
7      do i = 1, i
          r = r + i
      end do
10     return
C  END1

13     program testme
      call test()
      return

```

Testing other code environments. First Python:

```

!bc pycod
def f(x):
3     return x+1
!ec

```

which gets rendered as

```
2 def f(x):  
    return x+1
```

Test paragraph and subsubsection headings before before code.

```
1 import sys  
sys.path.insert(0, os.pardir)
```

Paragraph heading before code.

```
1 def h(z):  
    return z+1
```

Subsubsection heading before code.

Now a complete program to be shown via Python Online Tutorial:

```
1 class Line:  
    def __init__(self, a, b):  
        self.a, self.b = a, b  
4  
    def __call__(self, x):  
        a, b = self.a, self.b  
7        return a*x + b  
  
10 line = Line(2, 1)  
y = line(x=3)  
print(y)
```

(Visualize execution)

Some more Python code (actually specified as a sage cell, but such cells are not supported by this format).

```
1 a = 2  
b = 3  
print('a+b:', a + b)  
4
```

```

# In a sage cell we can also plot
from matplotlib.pyplot import *
7 from numpy import *
x = linspace(0, 4*pi, 101)
y = exp(-0.1*x)*cos(x)
10 plot(x, y)
xlabel('x'); ylabel('y')
show()

```

Then Cython (with -h option so it is hidden in html/sphinx):

```

cpdef f(double x):
    return x + 1

```

Standard Python shell sessions:

```

1 >>> from numpy import linspace, sin
>>> # Some comment
>>> x = linspace(0, 2, 11)
4 >>> y = sin(x)
>>> y[0]
0
7 >>> import matplotlib.pyplot as plt
>>> plt.plot(x, y)

```

Similar IPython sessions:

```

1 In [1]: from numpy import linspace, sin
In [2]: # Some comment
In [3]: x = linspace(0, 2, 11)
4 In [4]: y = sin(x)
In [5]: y[0]
Out[5]: 0
7 In [6]: import matplotlib.pyplot as plt
In [7]: plt.plot(x, y)
In [8]: a='multiple-\nline\noutput'
10 In [9]: a
Out[9]: 'multiple-\nline\noutput'
In [10]: print(a)
13 multiple-
line
output

```

Here is the interactive session again, but with `pysHELL-t`.

```
>>> from numpy import linspace, sin
>>> # Some comment
3 >>> x = linspace(0, 2, 11)
>>> y = sin(x)
>>> y[0]
6 0
>>> import matplotlib.pyplot as plt
>>> plt.plot(x, y)
```

C++:

```
1 #include <iostream>

int main()
4 {
    std::cout << "Sample output" << std::endl;
    return 0
7 }
```

And a little bit of Fortran: 🙄

```
!bc cod
2 subroutine midpt(x, length, a, b)
    real*8 a, b, x
    x = (a + b)/2
5    length = b - a
    return
    end
8 !ec
```

which then is typeset as

```
1 subroutine midpt(x, length, a, b)
    real*8 a, b, x
    x = (a + b)/2
4    length = b - a
    return
    end
```

HTML:

```
1 <table>
2 <tr><td>Column 1</td><td>Column 2</td></tr>
3 <tr><td>0.67526 </td><td>0.92871 </td></tr>
4 <!-- comment -->
5 </table>
```

But inline HTML code is also important, like text that starts with `<a href=`" (which can destroy the following text if not properly quoted).

Matlab with comments requires special typesetting:

```
1 % Comment on the beginning of the line can be escaped by %%
2 if a > b
3     % Indented comment needs this trick
4     c = a + b
5 end
```

And here is a system call:

Terminal

```
Terminal> mkdir test
Terminal> cd test
Terminal> myprog -f
output1
output2
```

Any valid pygments lexer/language name can appear to, e.g.,

```
1 !bc restructuredtext
2 =====
3 Heading
4 =====
5
6 Some text.
7 !ec
```

results in


```

=====
2  Heading
=====

5  Some text.

```

Finally, !bc do supports highlighting of DocOnce source:

```

1  ===== DocOnce test file =====

===== Computer code =====

4  Inline verbatim code, as in 'import numpy as np', is allowed, as well as
   code blocks:

7  !bc pycod
   from math import sin

10 def f(x):
    """Example on a function."""
13     return sin(x) + 1

   print(f(0))
16 !ec

19 ===== Mathematics =====

   Formulas can be inline, as in  $\nabla \cdot \mathbf{u} = 0$ , or typeset
22 as equations:

   !bt
25   \begin{align*}
   \nabla \cdot \mathbf{u} &= 0, \\
   \mathbf{u} &= \nabla \phi .
28   \end{align*}
   !et

31 === Subsubsection heading ===

   DocOnce files can have chapters, sections, subsections, and subsubsections.
34   __Paragraph heading.__ Paragraphs may have headings.

```

It is time to test verbatim inline font especially with a newline inside the text and an exclamation mark at the end: BEGIN! For spellcheck, test

a verbatim expression in another in a third. Also test exclamation mark as in `!bc` and `!ec` as well as `a != b`. Also test backslashes and braces like `\begin`, `\begin{enumerate}`, `\end{this}\end{that}`, and `{something \inside braces}`.

Here is some red color and an attempt to write with green color containing a `linebreak` code. Some formats will only display this correctly when `html` is the output format. But here some more running text is added which is not part of the previous blocks with line breaks.

Running OS commands.

Terminal

```
Terminal> python -c 'print("Testing\noutput\nfrom\nPython.")'
```

Testing
output
from
Python.

Footnotes. Here is a test of footnotes ¹, which are handy in text. They are used in different flavors, now in

- list items (note below that footnotes work after math, verbatim, and URLs - bin fact old and emphasize too!)
- even with math $\nabla^2 u^2$
- and code `h[i] += 1`³ (*must* have space between inline code and footnote!)
- and [links](#)⁴

which gives flexibility in writing. This is the third⁵ example.

Here is some more text before a new definition of a footnote that was used above.

Non-breaking space character.

This paragraph aims to test [non-breaking space character](#), and a typical example where this is needed is in physical units: 7.4 km is traveled

¹Typesetting of the footnote depends on the format. Plain text does nothing, \LaTeX removes the definition and inserts the footnote as part of the \LaTeX text. `reStructuredText` and `Sphinx` employ a similar type of typesetting as `Extended Markdown` and `DocOnce`, and in `HTML` we keep the same syntax, just displayed properly in `HTML`.

²Math footnotes can be dangerous since it interferes with an exponent.

³One-line footnote.

⁴[google.com](#) is perhaps the most famous web site today.

⁵Not much to add here, but the footnote is at the end with only one newline.

in $7.4/5.5 \approx 1.345$ s. Also check that a [link](#) is not broken across lines (drag the browser window to test this). (On the other hand, the tilde is used in computer code, e.g., as in `[x for x in y]` or in `y= x`, and should of course remain a tilde in those contexts.)

1.2 Subsection 2: Testing figures

Test of figures. In particular we refer to Figure 1 in which there is a flow.

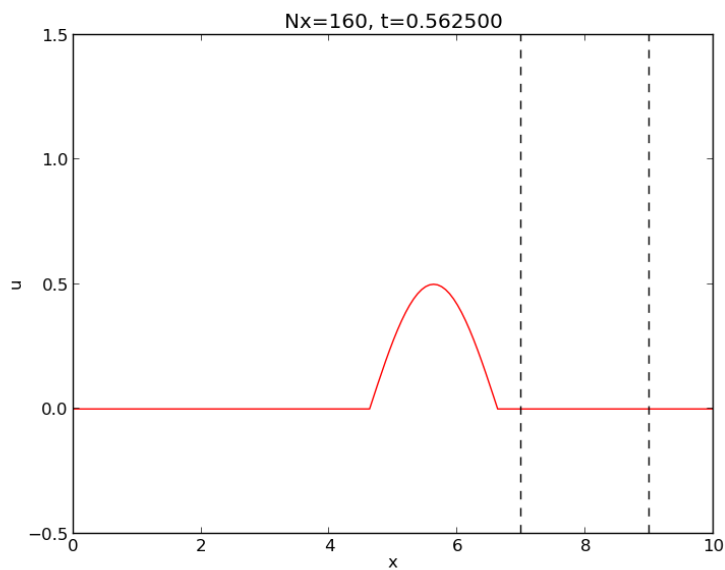
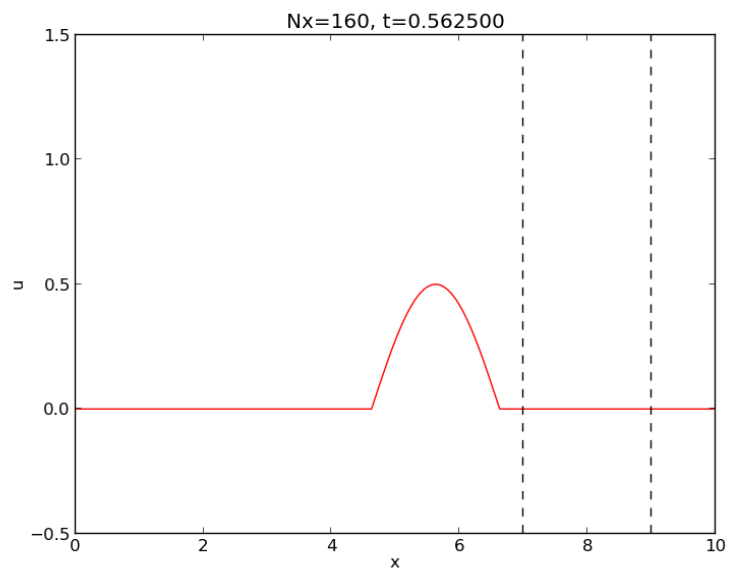
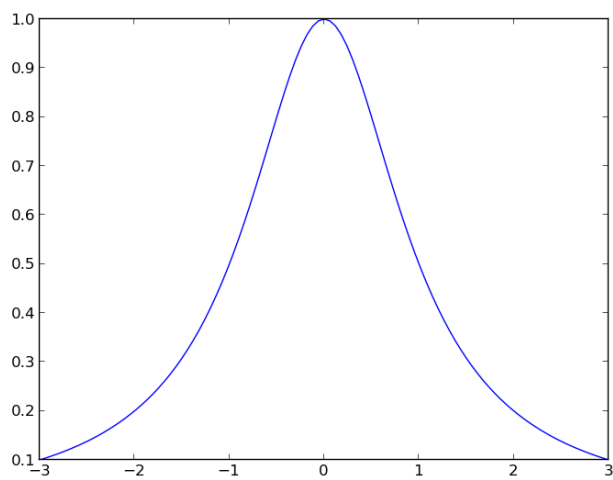


Figure 1: Visualization of a wave.

Figures without captions are allowed and will be inlined.



Here is figure 2 on page 13 with a long (illegal) multi-line caption containing inline verbatim text:
 Test URL as figure name:



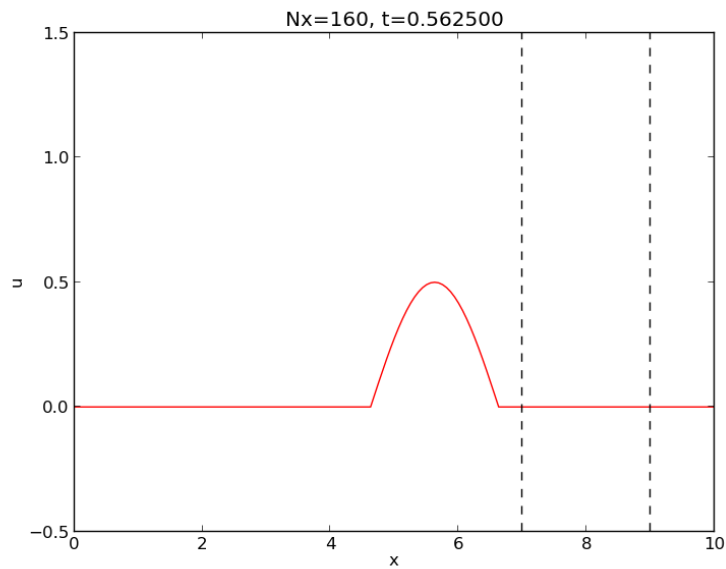


Figure 2:
A
long
cap-
tion
span-
ning
sev-
eral
lines
and
con-
tain-
ing
ver-
ba-
tim
words
like
my_file_v1
and
my_file_v2
as
well
as
math
with
sub-
script
as in
 t_{i+1} .

Remark. Movies are tested in separate file `movies.do.txt`.

1.3 The θ parameter (not ∇ ?)

Functions do not always need to be advanced, here is one involving θ :

```
1 def f(theta):
    return theta**2
```

More on θ . Here is more text following headline with math.

Newcommands must also be tested in this test report: $\frac{1}{2}$, $1/2$, \mathbf{x} , $\frac{Du}{dt}$, both inline and in block:

$$\frac{Du}{dt} = 0$$

$$\frac{1}{2} = 1/2 \tag{1}$$

$$\frac{1}{2}\mathbf{x} = \mathbf{n} \tag{2}$$

Or with align with label and numbers:

$$\frac{Du}{dt} = 0 \tag{3}$$

$$\frac{1}{2} = 1/2 \tag{4}$$

$$\frac{1}{2}\mathbf{x} = \mathbf{n} \tag{5}$$

First one numbered (automatically):

$$\begin{pmatrix} G_2 + G_3 & -G_3 & -G_2 & 0 \\ -G_3 & G_3 + G_4 & 0 & -G_4 \\ -G_2 & 0 & G_1 + G_2 & 0 \\ 0 & -G_4 & 0 & G_4 \end{pmatrix} = \begin{pmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{pmatrix} + \dots \tag{6}$$

$$\begin{pmatrix} C_5 + C_6 & -C_6 & 0 & 0 \\ -C_6 & C_6 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} = \frac{d}{dt} \begin{pmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ 0 \\ -i_0 \end{pmatrix}$$

Second numbered (automatically):

$$\begin{pmatrix} G_1 + G_2 & \\ -G_3 & G_4 \end{pmatrix} = \begin{pmatrix} v_1 \\ v_2 \end{pmatrix} + \dots$$

$$\begin{pmatrix} y & 2 \\ 2 & 1 \end{pmatrix} \begin{pmatrix} 0 \\ x \end{pmatrix} = \begin{pmatrix} A \\ B \end{pmatrix} \tag{7}$$

Both numbered, with label by the user:

$$\begin{pmatrix} G_1 + G_2 & \\ -G_3 & G_4 \end{pmatrix} = \begin{pmatrix} v_1 \\ v_2 \end{pmatrix} + \dots \tag{8}$$

$$\begin{pmatrix} y & 2 \\ 2 & 1 \end{pmatrix} \begin{pmatrix} 0 \\ x \end{pmatrix} = \begin{pmatrix} A \\ B \end{pmatrix} \tag{9}$$

Now we refer to (8)-(9).

Table 1: Testing table environment in L^AT_EX, enabled by testing on the "latex" format with the preprocessor.

time	velocity	acceleration
0.0	1.4186	-5.01
2.0	1.376512	11.919
4.0	1.1E+1	14.717624

1.4 Custom Environments

Here is an attempt to create a theorem environment via Mako (for counting theorems) and comment lines to help replacing lines in the .tex by proper begin-end L^AT_EX environments for theorems. Should look nice in most formats!

Theorem 5. Let $a = 1$ and $b = 2$. Then $c = 3$.

Proof. Since $c = a + b$, the result follows from straightforward addition. \diamond

As we see, the proof of Theorem 5 is a modest achievement.

1.5 Tables

Let us take this table from the manual:

The DocOnce source code reads

```

1 |-----|
4 |time | velocity | acceleration |
  |--l-----r-----r-----|
  | 0.0 | 1.4186 | -5.01 |
  | 2.0 | 1.376512 | 11.919 |
7 | 4.0 | 1.1E+1 | 14.717624 |
  |-----|

```

Here is yet another table to test that we can handle more than one table:

time	velocity	acceleration
0.0	1.4186	-5.01
1.0	1.376512	11.919
3.0	1.1E+1	14.717624

And one with math headings (that are expanded and must be treated accordingly), verbatim heading and entry, and no space around the pipe symbol:

i	h_i	\bar{T}_i	L_i
0	0	288	-0.0065
1	11,000	216	0.0
2	20,000	216	0.001
3	32,000	228	0.0028
4	47,000	270	0.0
5	51,000	270	-0.0028
6	71,000	214	NaN

And add one with verbatim headings (with underscores), and rows starting with | - because of a negative number, and | right before and after verbatim word (with no space):

exact	v_1	$a_i + v_2$	verb_3_
9	9.62	5.57	8.98
-20	-23.39	-7.65	-19.93
10	17.74	-4.50	9.96
0	-9.19	4.13	-0.26

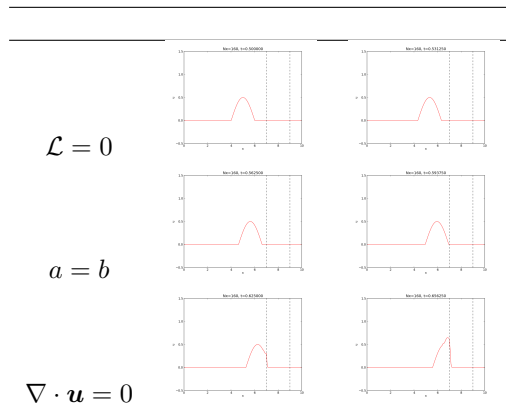
Pipe symbols in verbatim and math text in tables used to pose difficulties, but not anymore:

S	command
$ a_0 $	<code>norm length</code>
$x \cap y$	<code>x y</code>

Here is a table with X alignment:

Type	Description
X	Alignment character that is used for specifying a potentially very long text in a column in a table. It makes use of the <code>tabularx</code> package in L ^A T _E X, otherwise (for other formats) it means l (centered alignment).
l,r,c	standard alignment characters

Finally, a table with math and URLs.



1.6 A test of verbatim words in heading with subscript a_i : my_file_v1 and my_file_v2

Paragraph with verbatim and math: my_file_v1.py and my_file_v2.py define some math a_{i-1} . Here is more `__verbatim__` code and some plain text on a new line.

1.7 Just bold

Some text.

1.8 *Just emphasize*

Some text.

1.9 Just verbatim

Some text.

1.10 Bold beginning

Some text.

1.11 *Emphasize* beginning

Some text.

1.12 Verbatim beginning

Some text.

1.13 Maybe bold end

Some text.

1.14 Maybe *emphasize end*

Some text.

1.15 Maybe verbatim end

Some text.

1.16 The middle has bold word

Some text.

1.17 The middle has *emphasize* word

Some text.

1.18 The middle has verbatim word

Some text.

Just emphasize. Some text.

Just verbatim. Some text.

Emphasize beginning. Some text.

Verbatim beginning. Some text.

Maybe *emphasize end.* Some text.

Maybe verbatim end. Some text.

The middle has *emphasize* word. Some text.

The middle has verbatim word. Some text.

Ampersand. We can test Hennes & Mauritz, often abbreviated H&M, but written as Hennes & Mauritz and H & M. A sole & must also work.

```
# Just to check that ampersand works in code blocks:  
c = a & b
```

Quotes. Let us also add a test of quotes such as “double quotes, with numbers like 3.14 and newline/comma and hyphen (as in double-quote)”; written in the standard LaTeX-style that gives correct \LaTeX formatting and ordinary double quotes for all non-LaTeX formats. Here is another sentence that “caused” a bug in the past because double backtick quotes could imply verbatim text up to a verbatim word starting with period, like `.txt`.

More quotes to be tested for spellcheck: (“with parenthesis”), “with newline” and “with comma”, “hyphen”-wise, and “period”.

1.19 Bibliography test

Here is an example: [16] discussed propagation of large destructive water waves, [14] gave an overview of numerical methods for solving the Navier–Stokes equations, while the use of Backward Kolmogorov equations for analyzing random vibrations was investigated in [9]. The book chapter [18] contains information on C++ software tools for programming multigrid methods. A real retro reference is [6] about a big FORTRAN package. Multiple references are also possible, e.g., see [16, 18].

We need to cite more than 10 papers to reproduce an old formatting problem with blanks in the keys in reST format: [7, 9, 19, 16] and [14, 1, 20, 2, 10, 12, 15] and all the work of [13, 18, 3] as well as old work [6] and [5], and the talk [11]. Langtangen also had two thesis [4, 5] back in the days. More retro citations are the old ME-IN323 book [17] and the [8] OONSKI '94 paper.

Example 1: Examples can be typeset as exercises

Examples can start with a subsection heading starting with **Example:** and then, with the command-line option `--examples_as_exercises` be typeset as exercises. This is useful if one has solution environments as part of the example.

a) State some problem.

Solution. The answer to this subproblem can be written here.

b) State some other problem.

Hint 1. A hint can be given.

Hint 2. Maybe even another hint?

Solution. The answer to this other subproblem goes here, maybe over multiple doconce input lines.

1.20 User-defined environments

Example 1.1 demonstrates how to write a test function. That is, a special test function for a function `add` appears in Example 1.1.

Example 1.1. *A test function.*

Suppose we want to write a test function for checking the implementation of a Python function for addition.

```
1  def add(a, b):  
    return a + b  
  
4  def test_add():  
    a = 1; b = 1  
    expected = a + b  
7  computed = add(a, b)  
    assert expected == computed
```

Example 1.2. *Addition.*

We have

$$1 + 1 = 2$$

or in tabular form:

Problem	Result
1 + 1	2

Highlight box!

This environment is used to highlight something:

$$E = mc^2$$

1.21 URLs

Testing of URLs: hpl’s home page `hpl`, or the entire URL if desired, `https://folk.uio.no/hpl`. Here is a plain file link `testdoc.do.txt`, or `testdoc.do.txt`, or `testdoc.do.txt` or `testdoc.do.txt` or a link with newline. Can test spaces with the link with word too: `hpl` or `hpl`. Also `file:///` works: `link to a file` is fine to have. Moreover, “loose” URLs work, i.e., no quotes, just the plain URL as in `https://folk.uio.no/hpl`, if followed by space, comma, colon, semi-colon, question mark, exclamation mark, but not a period (which gets confused with the periods inside the URL).

Mail addresses can also be used: `hpl@simula.no`, or just a `mail link`, or a raw `mailto:hpl@simula.no`.

Here are some tough tests of URLs, especially for the `latex` format: `Newton-Cotes` formulas and a `good book`. Need to test Newton-Cotes with percent-age in URL too: `https://en.wikipedia.org/wiki/Newton%E2%80%93Cotes_formulas` and `https://en.wikipedia.org/wiki/Newton-Cotes#Open_Newton.E2.80.93Cotes_formulae` which has a shebang.

For the `-device=paper` option it is important to test that URLs with monospace font link text get a footnote (unless the `--latex_no_program_footnotelink` is used), as in this reference to `decay_mod`, `ball1.py`, and `ball2.py`.

More tough tests: repeated URLs whose footnotes when using the `-device=paper` option must be correct. We have `google`, `google`, and `google`, which should result in exactly three footnotes.

1.22 Test of Some L^AT_EX Fixes

Let's check abbr. of some common kind, e.g. the well-known i.e. expression as an example, and 1 vs. 2 which is also often used. Dr. Tang and Prof. Monsen, or maybe also prof. Ting, will go to the Dept. of Science to test how Mr. Hansen is doing together with Ms. Larsen. A reference like Sec. 1.21 on page 20 or Ch. 1.21 on page 20, or even App. 1.21 on page 20, must also be handled. Likewise, this is test no. *i* of DocOnce features. Also, look at Fig. 4 to see how the data compares with Tab. 1 on page 15. Percentage must be fixed: 7%, 87.65% and 50% at the beginning of the line.

2 L^AT_EX Mathematics

Here is an equation without label using backslash-bracket environment:

$$a = b + c$$

or with number and label, as in (10), using the equation environment:

$$\frac{\partial u}{\partial t} = \nabla^2 u \tag{10}$$

We can refer to this equation by (10).

Here is a system without equation numbers, using the align-asterisk environment:

$$\begin{aligned} \mathbf{a} &= \mathbf{q} \times \mathbf{n} \\ b &= \nabla^2 u + \nabla^4 v \end{aligned}$$

And here is a system of equations with labels in an align environment:

$$a = q + 4 + 5 + 6 \tag{11}$$

$$b = \nabla^2 u + \nabla^4 x \tag{12}$$

We can refer to (11)-(12). They are a bit simpler than the Navier–Stokes equations. And test L^AT_EX hyphen in CG-2. Also test a_{i-j} as well as $kx - wt$.

Testing `alignat` environment:

$$a = q + 4 + 5 + 6 \quad \text{for } q \geq 0 \tag{13}$$

$$b = \nabla^2 u + \nabla^4 x \quad x \in \Omega \tag{14}$$

Many of the next environments will fail in non-latex formats. Testing multiline:

$$a = b = q + f + \nabla \cdot \nabla u \tag{15}$$

Testing split:

$$a = b = q + f + \nabla \cdot \nabla u \tag{16}$$

We can refer to the last equation by (16).

Testing gather:

$$a = b \tag{17}$$

$$c = d + 7 + 9 \tag{18}$$

Let us refer to (11)-(12) again, and to the alignat variant (13)-(14), and to (10).

Testing eqnarray:

$$\frac{\partial u}{\partial t} = \nabla^2 u + f, \tag{19}$$

$$\frac{\partial v}{\partial t} = \nabla \cdot (q(u) \nabla v) + g \tag{20}$$

More mathematical typesetting is demonstrated in the coming exercises.

Below, we have Problem 2 and Project 4 on page 24, as well as Projects 5 on page 24 and 10 on page 28, and in between there we have Exercise 9 on page 28.

3 Exercises

Problem 2: Flip a Coin

a) Make a program that simulates flipping a coin N times. Print out “tail” or “head” for each flip and let the program count the number of heads.

Hint 1. Use `r = random.random()` and define head as `r <= 0.5`.

Hint 2. Draw an integer among $\{1, 2\}$ with `r = random.randint(1,2)` and define head when `r` is 1.

Answer. If the `random.random()` function returns a number $< 1/2$, let it be head, otherwise tail. Repeat this N number of times.

```
1 import sys, random
  N = int(sys.argv[1])
  heads = 0
4 for i in range(N):
    r = random.random()
    if r <= 0.5:
7         heads += 1
  print('Flipping a coin %d times gave %d heads' % (N, heads))
```

Solution.

b) Vectorize the code in a) using boolean indexing.

Vectorized code can be written in many ways. Sometimes the code is less intuitive, sometimes not. At least there is not much to find in [Section 1 on page 2](#).

c) Vectorize the code in a) using `numpy.sum`.

Answer. `np.sum(np.where(r <= 0.5, 1, 0))` or `np.sum(r <= 0.5)`.

In this latter subexercise, we have an example where the code is easy to read.

My remarks. Remarks with such a subsubsection is treated as more text after the last subexercise. Test a list too:

1. Mark 1.
2. Mark 2.

Filenames: `flip_coin.py`, `flip_coin.pdf`.

Remarks. These are the exercise remarks, appearing at the very end.

3.1 Not an exercise

Should be possible to stick a normal section in the middle of many exercises.

Exercise 3: Test of plain text exercise

Very short exercise. What is the capital of Norway? Filename: `myexer1`.

Project 4: Compute a Probability

What is the probability of getting a number between 0.5 and 0.6 when drawing uniformly distributed random numbers from the interval $[0, 1)$?

At the end we have a list because that caused problems in \LaTeX in previous DocOnce versions:

1. item1
2. item2

Hint. To answer this question empirically, let a program draw N such random numbers using Python's standard `random` module, count how many of them, M , that fall in the interval $(0.5, 0.6)$, and compute the probability as M/N .

Project 5: Explore Distributions of Random Circles

The formula for a circle is given by

$$x = x_0 + R \cos 2\pi t, \quad (21)$$

$$y = y_0 + R \sin 2\pi t, \quad (22)$$

where R is the radius of the circle, (x_0, y_0) is the center point, and t is a parameter in the unit interval $[0, 1]$. For any t , (x, y) computed from (21)-(22) is a point on the circle. The formula can be used to generate `n` points on a circle:

```
1  import numpy as np
   def circle(R, x0, y0, n=501):
4     t = np.linspace(0, 1, n)
     x = x0 + R*np.cos(2*np.pi*t)
     y = y0 + R*np.sin(2*np.pi*t)
7     return x, y
   x, y = circle(2.0, 0, 0)
```

The goal of this project is to draw N circles with random center and radius. Plot each circle using the `circle` function above.

- a) Let R be normally distributed and (x_0, y_0) uniformly distributed.

Hint. Use the `numpy.random` module to draw the x_0 , y_0 , and R quantities.

Answer. Here goes the short answer to part a).

Solution. Here goes a full solution to part a).

b) Let R be uniformly distributed and (x_0, y_0) normally distributed. Filename: `norm`.

c) Let R and (x_0, y_0) be normally distributed. Filename: `circles`.

Remarks. At the very end of the exercise it may be appropriate to summarize and give some perspectives.

Exercise 6: Determine some Distance

Intro to this exercise. Questions are in subexercises below.

Solution. Here goes a full solution of the whole exercise. With some math $a = b$ in this solution:

math in solution: $a = b$

And code `a=b` in this solution:

```
a = b # code in solution
```

End of solution is here.

a) Subexercises are numbered a), b), etc.

Hint 1. First hint to subexercise a). With math $a = b$ in hint:

$$a = b.$$

And with code (in plain verbatim) returning $x + 1$ in hint:

```
def func(x):  
    return x + 1 # with code in hint
```

2

Hint 2. Second hint to subexercise a).

Test list in hint:

1. item1
2. item2

Filename: `subexer_a.pdf`.

Answer. Short answer to subexercise a). With math in answer: $a = b$.

b) Here goes the text for subexercise b).

Some math $\cos^2 x + \sin^2 x = 1$ written on a single line:

$$\cos^2 x + \sin^2 x = 1 .$$

Hint. A hint for this subexercise.

Filename: `subexer_b.pdf`.

Solution. Here goes the solution of this subexercise.

The text here belongs to the main (intro) part of the exercise. Need closing remarks to have text after subexercises.

Test list in exercise:

1. item1
2. item2

Remarks. Some final closing remarks, e.g., summarizing the main findings and their implications in other problems can be made. These remarks will appear at the end of the typeset exercise.

Some exercise without the "Exercise:" prefix

Just some text. And some math saying that $e^0 = 1$ on a single line, to test that math block insertion is correct:

$$\exp(0) = 1$$

And a test that the code `lambda x: x+2` is correctly placed here:

```
1 lambda x: x+2
```

Exercise 7: Solution of differential equation

Solution of differential equation

Given

$$\frac{dy}{dx} = -y(x), \quad y(0) = 1$$

What is the solution of this equation?

- A. $y = e^{-y}$
- B. $y = e^y$
- C.

```
2 from math import exp
def f(x):
    return exp(x)
```

- D. The solution cannot be found because there is a derivative in the equation.
- E. The equation is meaningless: an equation must be an equation for x or y , not a function $y(x)$.

Answer: A.

Solution:

- A: Right.
- B: Wrong. Almost, but the sign is wrong (note the minus!).
- C: Wrong. Oops, forgot a minus: `exp(-x)`, otherwise this Python code must be considered as a good answer. It is more natural, though, to write the solution to the problem in mathematical notation:

$$y(x) = e^{-x}.$$

D: Wrong. Equations with derivatives can be solved; they are termed *differential equations*.

E: Wrong. Equations where the unknown is a function, as $y(x)$ here, are called *differential equations*, and are solved by special techniques.

Example 8: Just an example

a) What is the capital of Norway?

Answer. Oslo.

4 Here goes another section

With some text, before we continue with exercises.

5 More Exercises

Exercise 9: Make references to projects and problems

Pick a statement from Project 5 on page 24 or Problem 2 on page 22 and verify it.

Test list at the end of an exercise without other elements (like subexercise, hint, etc.):

1. item1
2. item2

Filename: `verify_formula.py`.

Project 10: References to Project 4 on page 24 in a heading works for pdflatex

Refer to the previous exercise as Exercise 9, the two before that as Projects 4 on page 24 and 5 on page 24, and this one as Project 10. Filename: `selc_composed.pdf`.

References

- [1] S. Glimsdal, G. Pedersen, K. Atakan, C. B. Harbitz, H. P. Langtangen, and F. Løvholt. Propagation of the Dec. 26, 2004 Indian Ocean Tsunami: Effects of dispersion and source characteristics. *International Journal of Fluid Mechanics Research*, 33(1):15–43, 2006.
- [2] J. B. Haga, H. Osnes, and H. P. Langtangen. On the causes of pressure oscillations in low-permeable and low-compressible porous media. *International Journal of Analytical and Numerical Methods in Geomechanics*, 2011.
- [3] P. V. Jeberg, H. P. Langtangen, and C. B. Terp. Optimization with Diffpack: Practical example from welding. Report 2004-12, Simula Research Laboratory, 2004.
- [4] H. P. Langtangen. Solution of the Navier-Stokes equations with the finite element method in two and three dimensions, 1985. Cand.Scient. thesis.
- [5] H. P. Langtangen. Computational methods for two-phase flow in oil reservoirs, 1989. Dr. Scient. thesis.

- [6] H. P. Langtangen. The FEMDEQS program system. Research report in mechanics, Department of Mathematics, University of Oslo, 1989.
- [7] H. P. Langtangen. Stochastic breakthrough time analysis of an enhanced oil recovery process. *SIAM Journal on Scientific Computing*, 13:1394–1417, 1992.
- [8] H. P. Langtangen. Diffpack: Software for partial differential equations. In A. Vermeulen, editor, *Proceedings of the Second Annual Object-Oriented Numerics Conference (OON-SKI'94)*, Sunriver, Oregon, USA, 1994.
- [9] H. P. Langtangen. Numerical solution of first passage problems in random vibrations. *SIAM Journal of Scientific and Statistical Computing*, 15:997–996, 1994.
- [10] H. P. Langtangen. *Computational Partial Differential Equations - Numerical Methods and Diffpack Programming*. Texts in Computational Science and Engineering. Springer, second edition, 2003.
- [11] H. P. Langtangen. Computational modeling of huge tsunamis from asteroid impacts. Invited keynote lecture at the *International conference on Computational Science 2007 (ICCS'07)*, Beijing, China, May 2007.
- [12] H. P. Langtangen. *Python Scripting for Computational Science*. Texts in Computational Science and Engineering. Springer, third edition, 2008.
- [13] H. P. Langtangen. *A Primer on Scientific Programming With Python*. Texts in Computational Science and Engineering. Springer, third edition, 2012.
- [14] H. P. Langtangen, K.-A. Mardal, and R. Winther. Numerical methods for incompressible viscous flow. *Advances in Water Resources*, 25:1125–1146, 2002.
- [15] H. P. Langtangen and G. Pedersen. *Finite Elements for the Boussinesq Wave Equations*, pages 117–126. Kluwer Academic Publishers, 1995.
- [16] H. P. Langtangen and G. Pedersen. Propagation of large destructive waves. *International Journal of Applied Mechanics and Engineering*, 7(1):187–204, 2002.
- [17] H. P. Langtangen and A. Tveito. Numerical methods in continuum mechanics. Si-report, Center for Industrial Research, 1991. Lecture notes for a course (ME-IN 324). 286 pages.
- [18] K.-A. Mardal, G. W. Zumbusch, and H. P. Langtangen. Software tools for multigrid methods. In H. P. Langtangen and A. Tveito, editors, *Advanced Topics in Computational Partial Differential Equations – Numerical Methods and Diffpack Programming*, Lecture Notes in Computational Science and Engineering, pages 97–152. Springer, 2003.

- [19] M. Mortensen, H. P. Langtangen, and G. N. Wells. A FEniCS-based programming framework for modeling turbulent flow by the Reynolds-averaged Navier-Stokes equations. *Advances in Water Resources*, 34(9), 2011.
- [20] S. Rahman, J. Gorman, C. H. W. Barnes, D. A. Williams, and H. P. Langtangen. Numerical investigation of a piezoelectric surface acoustic wave interaction with a one-dimensional channel. *Physical Review B: Condensed Matter and Materials Physics*, 74, 2006. 035308.

A Just for testing; part I

This is the first appendix.

A.1 A subsection within an appendix

Some text.

B Just for testing; part II

This is more stuff for an appendix.

B.1 Appendix: Testing identical titles

Without label.

B.2 Appendix: Testing identical titles

With label.

B.3 Appendix: Testing identical titles

What about inserting a quiz?

Capital of Norway

Fundamental test: What is the capital of Norway?

- A. Stockholm
- B. London
- C. Oslo
- D. Bergen

Answer: C.

Solution:

A: Wrong. Stockholm is the capital of Sweden.

B: Wrong.

C: Right.

D: Wrong. Those from Bergen would claim so, but nobody else.

B.4 Appendix: Testing identical titles

Without label.

Tip.

Here is a tip or hint box, typeset as a notice box.

Need a lot of text to surround the summary box. Version control systems allow you to record the history of files and share files among several computers and collaborators in a professional way. File changes on one computer are updated or merged with changes on another computer. Especially when working with programs or technical reports it is essential to have changes documented and to ensure that every computer and person involved in the project have the latest updates of the files. Greg Wilson's excellent [Script for Introduction to Version Control](#) provides a more detailed motivation why you will benefit greatly from using version control systems.

Summary.

Bold remark: Make some text with this summary. Much testing in this document, otherwise stupid content. Much testing in this document, otherwise stupid content. Much testing in this document, otherwise stupid content. Much testing in this document, otherwise stupid content. Much testing in this document, otherwise stupid content. Much testing in this document, otherwise stupid content. Much testing in this document, otherwise stupid content. Much testing in this document, otherwise stupid content. Much testing in this document, otherwise stupid content. Much testing in this document, otherwise stupid content.

Projects that you want to share among several computers or project workers are today most conveniently stored at some web site "in the cloud" and updated through communication with that site. I strongly recommend you to use such sites for all serious programming and scientific writing work - and all other important files.

The simplest services for hosting project files are [Dropbox](#) and [Google Drive](#). It is very easy to get started with these systems, and they allow you to share files among laptops and mobile units with as many users as you want. The systems offer a kind of version control in that the files are stored frequently (several times per minute), and you can go back to previous versions for the last 30 days. However, it is challenging to find the right version from the past when there are so many of them.

More seriously, when several people may edit files simultaneously, it can be difficult to detect who did what when, roll back to previous versions, and to manually merge the edits when these are incompatible. Then one needs more sophisticated tools than Dropbox or Google Drive: project hosting services with true version control systems. The following text aims at providing you with the minimum information to start with such systems. Numerous other tutorials contain more comprehensive material and in-depth explanations of the concepts and tools.

The idea with project hosting services is that you have the files associated with a project in the cloud. Many people may share these files. Every time you want to work on the project you explicitly update your version of the files, edit the files as you like, and synchronize the files with the "master version" at

the site where the project is hosted. If you at some point need to go back to a version of the files at some particular point in the past, this is an easy operation. You can also use tools to see what various people have done with the files in the various versions.

All these services are very similar. Below we describe how you get started with Bitbucket, GitHub, and Googlecode. Launchpad works very similarly to the latter three. All the project hosting services have excellent introductions available at their web sites, but the recipes below are much shorter and aim at getting you started as quickly as possible by concentrating on the most important need-to-know steps. The Git tutorials we refer to later in this document contain more detailed information and constitute of course very valuable readings when you use version control systems every day. The point now is to get started.

B.5 Appendix: Testing inline comments

Projects that you want to share among several computers or project workers are today most conveniently stored at some web site "in the cloud" and updated through communication with that site. **hpl's semi opinion 1: not sure if in the cloud is understood by all.** I strongly recommend you to use such sites for all serious programming and scientific writing work - and all other important files.

The simplest services for hosting project files is Dropbox. **mp 2: Simply go to <https://dropbox.com> and watch the video. It explains how files, like `myfile.py`, perhaps containing much math, like $\partial u/\partial t$, are easily communicated between machines.** It is very easy to get started with Dropbox, and it allows you to share files among **(hpl 3:) laptops-and-mobile-units** computers, tablets, and phones.

First, **(edit 4: add comma)** consider a quantity Q . **(edit 5:) ~~To this end,~~ We note that $Q > 0$, because (edit 6:) ~~a~~ negative (edit 7:) ~~quantity is~~ quantities are (edit 8:) ~~just~~ negative. (edit 9:) This comes as no surprise.**

Let us refer to Figure 1 on page 11 again.

Test references in a list:

- 1 on page 2
- 1.1 on page 3
- 1 on page 11

B.6 Appendix: Testing headings ending with verbatim inline

The point here is to test 1) verbatim code in headings, and 2) ending a heading with verbatim code as this triggers a special case in L^AT_EX.

We also test mdash—used as alternative to hyphen without spaces around, or in quotes:

Fun is fun.—Unknown.

The ndash should also be tested – as in the Hanson–Nilson equations on page 277–278.

And finally, what about admons, quotes, and boxes? They are tested in a separate document: `admon.do.txt`.

Index

boldface word in index, [15](#)

double **boldface word**
 boldface word in subentry too,
 [15](#)

figures, [11](#)

index with
 boldface word in subentry, [15](#)
 subindex, [15](#)

index with **boldface word**, [15](#)

index, with comma, and one more, [15](#)

movies, [12](#)

`somefunc` function, [3](#)

test index with `verbatim text` which
 is possible, [15](#)

test two (separate) `verbatim expressions`
 which is also possible, [15](#)