



UNIVERSITY OF THE PHILIPPINES

Bachelor of Science in Applied Physics

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*Modelling learning spread in classrooms using cellular automata
modelling*

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ENDORSEMENT

This is to certify that this thesis entitled **Modelling learning spread in classrooms using cellular automata modelling**, prepared and submitted by Clarence Ioakim T. Sy in partial fulfillment of the requirements for the degree of Bachelor of Science in Applied Physics, is hereby accepted.

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Thesis Adviser

The National Institute of Physics endorses acceptance of this thesis in partial fulfillment of the requirements for the degree of Bachelor of Science in Applied Physics.

WILSON O. GARCIA, Ph.D.
Director
National Institute of Physics

To thinking complexly

Acknowledgments

I would like to thank...

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ABSTRACT

MODELLING LEARNING SPREAD IN CLASSROOMS USING CELLULAR AUTOMATA MODELLING

Clarence Ioakim T. Sy
University of the Philippines (2024)

Adviser:
Johnrob Y. Bantang, Ph.D.

This becomes the abstract of the work. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog.

The quick brown fox jumps over the lazy dog. The quick brown fox jumps over
the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox
jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick
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fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick
brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog.

[illegible]

PACS: 01.20.+x [Communication forms and techniques (written, oral, electronic, etc.)], 01.30mm (Textbooks for graduates and researchers)

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Chapter 1

Introduction, Hello world

This is hello world[1–3]. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog.

Note the presence of `\hspace{\parindent}` before the first paragraph of this section. It forces the indentation of the first paragraph. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog.

You may force the appearance of new page using the command `\newpage`.

Behold, a new page appears.

1.1 First section

This is the first section. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog.

The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog.

The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog.

1.2 Second section

This is the second section. The quick brown fox jumps over the lazy dog near the bank of the river. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog.

The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog.

Chapter 2

Review of Literature

In this chapter, a review of literature related to the problem statement or the area of research is presented. In this chapter, it is expected that a lot of citations are needed. The creation of `*.bib` file might be necessary. You may need to run `bibtex` to create `bbl` files for your `main.tex`.

2.1 Separation of chapters into different files

The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog.

The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog. The quick brown fox jumps over the lazy dog.

Chapter 3

Customized Chapter

This is a customized chapter.

3.1 First section

You may change the filename of this file as long as you correspondingly change the filename stated in the `input{}` line in the `main.tex`.

3.2 Including figures

Figures can be added into your \LaTeX files using the `figure` environment. However, it is **recommended** that you use `.eps` file format. These are encapsulated postscript files. This can be easily done by installing a postscript printer that outputs to a file (port is `FILE`). Ask your system administrator to install such a device for producing `eps` files by simply printing it to that device.

Shown in Fig. 3.1 is a figure created from Excel®. Note that the bounding box and page bounding box should be adjusted well enough to show the correct field.

Please see the sample chapter on how the figure is included in the `tex` files.

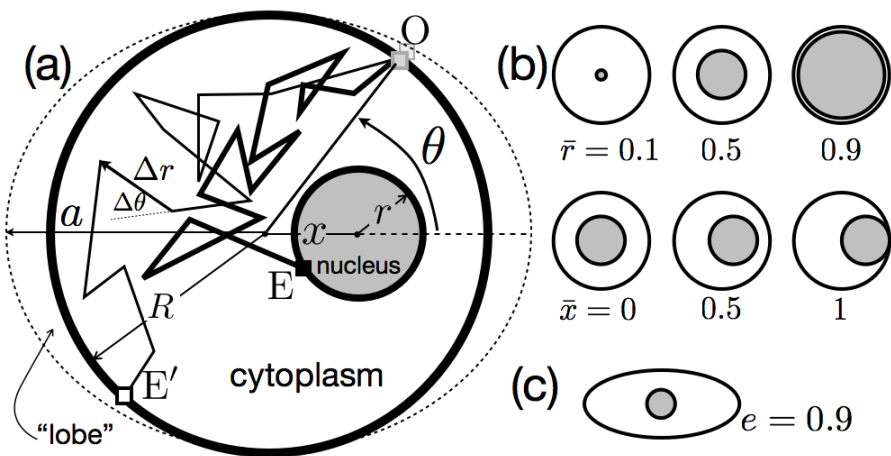


Figure 3.1: A *.png file.

Chapter 4

Another Customized Chapter

In this chapter, a sample for making equations and sub-equations are demonstrated.

4.1 Equations and sub-equations

In the following, a set of equations is shown.

$$\vec{\nabla} \cdot \vec{D} = \rho \tag{4.1a}$$

$$\vec{\nabla} \cdot \vec{B} = 0 \tag{4.1b}$$

$$\vec{\nabla} \times \vec{E} = -\partial_t \vec{B} \tag{4.1c}$$

The last one being

$$\vec{\nabla} \times \vec{H} = \vec{J} + \partial_t \vec{D} \tag{4.1d}$$

Note that text can still be placed between sub-equations within the `subequations` environment.

When using a solitary equations, you may use the usual equation syntax in L^AT_EX.

$$E = mc^2 \tag{4.2}$$

Chapter 5

Summary and Conclusions

A short sample thesis/dissertation is presented. Although not complete, it will be useful for newbies in L^AT_EX. Any questions? email me at the following address: johnrob.bantang@gmail.com.

Appendix A

Sample appendix

This gives an example of an appendix chapter. Note that this file has been included **after** the line `\appendix` in `main.tex`.

A.1 Equations in appendix

You don't need to worry about equations within the appendix since \LaTeX automatically formats the equation numbers for you. For example,

$$c^2 = a^2 + b^2 \tag{A.1}$$

becomes the Pythagorean theorem where c is the length of the longest side of any right triangle.

A.2 Codes as appendix

Include your codes when necessary to your thesis/dissertation. To do this, you may use `verbatim` environment as follows. **WARNING:** All `verbatim` and `verbatiminput` environments should always be treated as a separate paragraph. When included in a text paragraph, it sometimes happen to reduce the 1.5 spacing to the usual single-spaced text.

```
#include <iostream>
using std::cout;
using std::endl;

int main( void )
{
    cout << "Hello world!" << endl;
    return 0;
}
```


The `{\small }` bracketed region is used to lower the font size of the entire verbatim text. This will save you much space and give a more aesthetical look in your manuscript.

On the other hand, when very long codes are wished to be included automatically without the tedious cut and paste procedure, you may include them using the `\verbatiminput` command as follows. You may want to include a short description of the code of course.

```
//Johnrob Y. Bantang, Natinal Institute of Physics
//Created: 03 October 2002
// Makes new C files
// usage: newC filename
//Modifications:
// >> 21 Jan 2003, Johnrob
//   included the constant AUTHOR and AFFILIATION for portability

#include <stdlib.h>
#include <iostream.h>
#include <fstream.h>
#include <strstream.h>
#include <time.h>
#include <string.h>

const char *const AUTHOR= "Johnrob Y. Bantang";
const char *const AFFILIATION= "National Institute of Physics";
const char *const EXTENSION= ".cpp";

int main(int argc,char **argv){
if(argc!=2){
cout<<"usage: newC filename"<<endl;
exit(0);
}
char *fname= new char[strlen(argv[1])+5];
ostrstream out(fname,strlen(argv[1])+5);
out<<argv[1]<<EXTENSION;
time_t date=time(NULL);

ofstream file(fname,ios::nocreate,0);
//opens normal file that **already exists**;
if(file){
for(int i=1;i<5;i++)
cout<<"WARNING! file aready exists!"<<endl;
cout<<endl<<"you can type"<<endl<<endl;
cout<<"\t\"head "<<fname<<"\"<<endl;
cout<<"in command line to *view version*"<<endl<<endl;
cout<<"please enter 1 to OVERWRITE this file"<<endl;
```

```

cout<<"type anything to cancel"<<endl;
for(int i=1;i<5;i++)
cout<<"WARNING! file already exists!"<<endl;
int n;
cin>>n;
if(n!=1){
cout<<"*no* file is created... exiting..."<<endl<<endl;
exit(0);
}
file.close();
file.open(fname);
if(!file)
cout<<"**cannot create new file!**"<<endl;
cout<<"OLD FILE: "<<fname<<" *overwritten!*"<<endl;
}
if(!file){
file.open(fname);
if(!file){
cout<<"**cannot create new file!**"<<endl;
exit(0);
}
cout<<endl<<"NEW FILE created: "<<fname<<endl<<endl;
}

cout<<"\tcreating contents for the new C++ file: "<<endl<<endl;
//creating headers...
file<<"//filename: \""<<fname<<"\"<<endl;
file<<"//\"<<AUTHOR<<\", \"<<AFFILIATION<<endl;
file<<"//Created: \"<<asctime( localtime(&date) );
//writes the time and date today; endl already in asctime();
file<<"//\"<<endl;
file<<"//Comments:\"<<endl;
file<<"// >>\"<<endl;
file<<"//\"<<endl;
file<<"//This file is generated using the \"newC generator\"..."<<endl;
file<<"//Modifications:\"<<endl;
file<<"// >>\"<<endl<<endl;
file<<"#include <iostream.h>\"<<endl;
file<<"#include <math.h>\"<<endl<<endl;
//starting the main body...
file<<"int main(int argc,char **argv){\"<<endl;
file<<"//\tif(argc!= ...){\"<<endl;
file<<"//\t\tcout<<\"usage: \"<<argv[1]<<\".exe ... \"<<endl;<<endl;
file<<"//\t\texit(1);\"<<endl;
file<<"//\t}\"<<endl;
file<<"\t//write the main body here\"<<endl;
file<<"return(0);\"<<endl<<\"}\"<<endl;

delete fname;

```

```
    file.close();  
    cout<<endl<<"\tCREATION SUCCESSFUL!"<<endl<<endl;  
return 0;  
}
```

This time, you may just include your recent codes by just copy-paste-ing the codes (as long they are clean!) into the directory `codes/` in the directory where this file is saved.

Bibliography

- [1] J. Goodman. *Introduction to Fourier Optics*. McGraw-Hill Book Co., San Francisco, 1968.
- [2] G.A. Mourou, C.P.J. Barty, and M.D. Perry. Ultrahigh-intensity lasers: Physics of the extreme on a tabletop. *Applied Optics*, 51(1):22–28, January 1998.
- [3] G. Steinmeyer, D. Sutter, L. Gallman, N. Matuschek, and U. Keller. Frontiers in ultrashort pulse: Pushing the limits in linear and non-linear optics. *Science*, 286(5544), 1999.