Lab #1

Computational Physics I (**Phys381**)
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Due January 16, 2014 (at the end of class)

[**Total: 100 marks including 20 marks for the report**]

- The latexed report is worth **20%** of the total mark. Only well documented and neatly presented reports will be worth that much! It is not sufficient to give only numerical results and show plots, you should also discuss your results. Include complete figure captions, introduction and conclusion sections.
- Your report must be in a *two-column format*.
- Your report should include your *Fortran code* and *Gnuplot scripts* in an Appendix using the *verbatim* command.
- If applicable, animations should be shown to the teacher and/or TA before handing in the lab report. The animation should be well documented and contains necessary information (student name, assignment number, run time etc ...). Basically, the information should be included in each frame before they are put together.
- You must name your report using the names (last names only): *student1-student2-phys381-lab#.pdf*.
- **Procedure for Handing in your lab report (see instructions on phys381 wbsite)**:

  1) Set permission to your PDF report as 644. It means:
  chmod 644 *student1-student2-phys381-lab#.pdf*
  2) cp -a *student1-student2-phys381-lab#.pdf* **/home/ambrish/phys381/labs/lab#**
  3) Copy a second time to ensure that your exam copied correctly. If you are prompted as to whether or not you would like to replace the existing file, then you report has been successfully submitted.

- **You must check with your TAs (Ambrish or Zach) that your report was received and is readable BEFORE you leave the lab.**

1 A Wave Packet

[Total: 100 marks]

The purpose of this laboratory is to introduce you to the basics of **Gnuplot** and Latex. In this laboratory you will also be generating an animation. This laboratory is based on **question 44** in Appendix C of the Ouyed&Dobler lecture notes.

The function

$$f(x,t) = \exp(-(x - 3\ t)^2) \times \sin(3\ \pi\ (x - t))\ , \tag{1}$$

describes for a fixed value of time, t, a wave localized in space.

a) Write a gnuplot script (see C.1.9 in Ouyed&Dobler) that plots this function as a function of x on the interval [-4,4] when t=0. Include the figure in your latex document and comment it. **[20 marks]**

b) Here you will be using Gnuplot to plot the function at 3 different times on the same figure. You will need to use the *multiplot* command (see C.1.4 in Ouyed&Dobler). Write a gnuplot script that plots this function as a function of x on the interval [-6,6] for $t = -1$, $t = 0$ and $t = +1$. In other words, the figure consists of 3 panels. Include the figure in your latex document and comment it. **[20 marks]**

c) Write a gnuplot script that plots $f(x,t)$ as a 2-dimensional surface in the intervals $x = [-6, 6]$ and $t = [-1, 1]$ (see C.1.7 in Ouyed&Dobler). Compare to plots you obtained in (a) and (b) above. Which plot carries more information about the wave packet? Include the figure in your latex document and comment it. **[20 marks]**

d) Make an animated GIF file following instructions provided in Appendix C below (see also instructions provided in the boxes following question 44 in appendix C in Ouyed&Dobler). **[20 marks]**

(You will see that $f(x,t)$ models waves that are moving to the right (when x is a space coordinate and t is time). The velocity of the individual waves and the packet is different, demonstrating a case in physics when the phase velocity of waves is different from the group velocity.)

A Gnuplot script: generating an ".eps" file

```
set terminal postscript
set output "test.eps"
set multiplot
set size 0.5,0.5
set xrange [-1:1]
set origin 0.0, 0.0
plot sin(x)
set origin 0.0, 0.5
plot cos(x)
```

```
set origin 0.5, 0.0
plot sin(x)*cos(x)
set origin 0.5, 0.5
plot sin(x)**2
!epstopdf "test.eps" && rm "test.eps"
unset multiplot
reset
```

ALWAYS USE "RESET" at the end or beginning of the script !

A.1 Gnuplot tricks

To set an "enhanced" EPS terminal:

```
set terminal postscript eps enhanced solid "Helvetica" 14
```

A label with an α in it

```
set label 1 at graph 0.1, 0.1 "{/Symbol a}^2 = 12"
```

B Gnuplot script: example 2

```
set term gif
set output "my.gif"
#
#  Before you plot:
#      set multiplot
#  THEN after plotting everything, before the "reset" call,
#      unset multiplot
#
set multiplot
set xrange [10:20]
set yrange [0:1]
#
# plot my function
#
plot cos(x)
#
#  arrows  (if you use arrow AFTER plot you must use REPLOT)
#
set arrow from 12,0.2 to 20,0.6  nohead lt -1 lw 2.2
#
```

```
#  plotting 3 different points
#
plot '-' w p ls 1, '-' w p ls 2, '-' w p ls 3
12 0.2
e
14 0.6
e
18 0.5
e
#
#  unset things
#
unset multiplot
reset
```

ALWAYS USE "RESET" at the end or beginning of the script !

C How to make the animations with Gnuplot

Under **gif terminal**, if the animate option is selected, Gnuplot will treat each plot as a frame of an animation.

C.1 Old versions of Gnuplot

For example:

```
#We will plot sin(x+t) in this gif animation
reset
set term gif animate
set output "phys381movie.gif"
n=24    #n frames
dt=2*pi/n
set xrange [0:4*pi]
i=0
load "animate.gnuplot"
```

where file "animate.gnuplot" contain the following gnuplot commands:

```
plot sin(x+i*dt) w l lt 1 lw 1.5 title sprintf("t=%i",i)
i=i+1
if (i < n) reread
```

C.2 Newest versions of Gnuplot (4.6 and above)

```
reset
set terminal gif animate delay 4
set output "phys381movie.gif"
n=24 #n frames
dt=2*pi/n
set xrange [0:4*pi]
set yrange [-1:1]
do for [i=0:n]{
  plot sin(x+i*dt)/(1. + i/12.) w l lw 1.5 title sprintf("t=%i",i)
}
```

C.3 To play your animation

Go to your linux prompt and type:

```
animate phys381movie.gif
```

the above command will play your movie.

D How to make the animations with Linux

- For each time step Δt generate a GIF file which shows the location of the wave packet. Each GIF (i.e. plot) should be fully annotated including a title.
- Once you have generated the GIF files you can make an mpeg movie using the "convert" command. To convert a series of numbered GIF files to a GIF movie:

  ```
  convert -delay 6 -quality 95 *.gif mymovie.gif
  ```

  -delay and -quality flags are optional. If -delay is set > 4, it will add extra frames to make the movie run more slowly, thereby increasing the size of the file. The default quality is 75 and maximum is 100.
- Check your movie by viewing it using the **animate** command:

  animate mymovie.gif