问题求解与实践
——GUI编程（1）

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Chapter 12
A display model

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Overview

- Why graphics?
- A graphics model
- Examples

Why bother with graphics and GUI?

- It' s very common
  - If you write conventional PC applications, you'll have to do it
- It' s useful
  - Instant feedback
  - Graphing functions
  - Displaying results
- It can illustrate some generally useful concepts and techniques

Why bother with graphics and GUI?

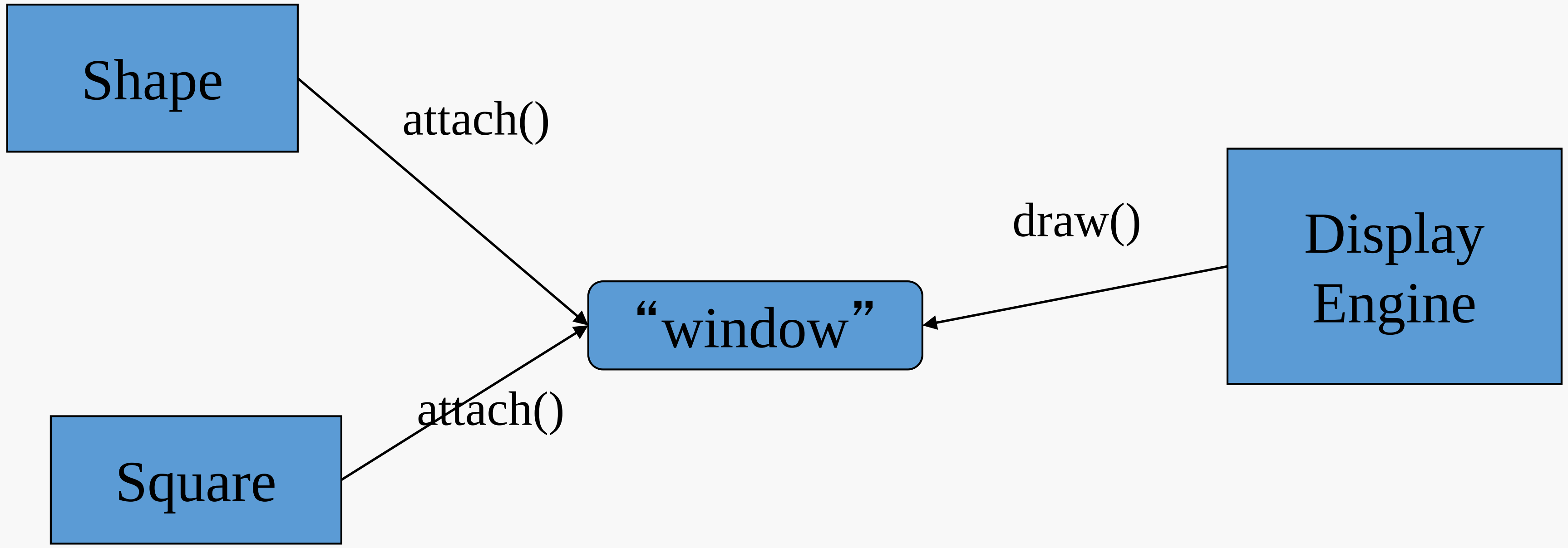
- It can only be done well using some pretty neat language features ☺
- Lots of good (small) code examples
- It can be non-trivial to "get" the key concepts
  - So it's worth teaching
  - If we don't show how it's done, you might think it was "magic"
- Graphics is fun!

Why Graphics/GUI?

- WYSIWYG
  - What you see (in your code) is what you get (on your screen)
- Direct correspondence between concepts, code, and output

Display model

- Objects (such as graphs) are “attached to” a window.
- The “display engine” invokes display commands (such as “draw line from x to y”) for the objects in a window
- Objects such as Square contain vectors of lines, text, etc. for the window to draw

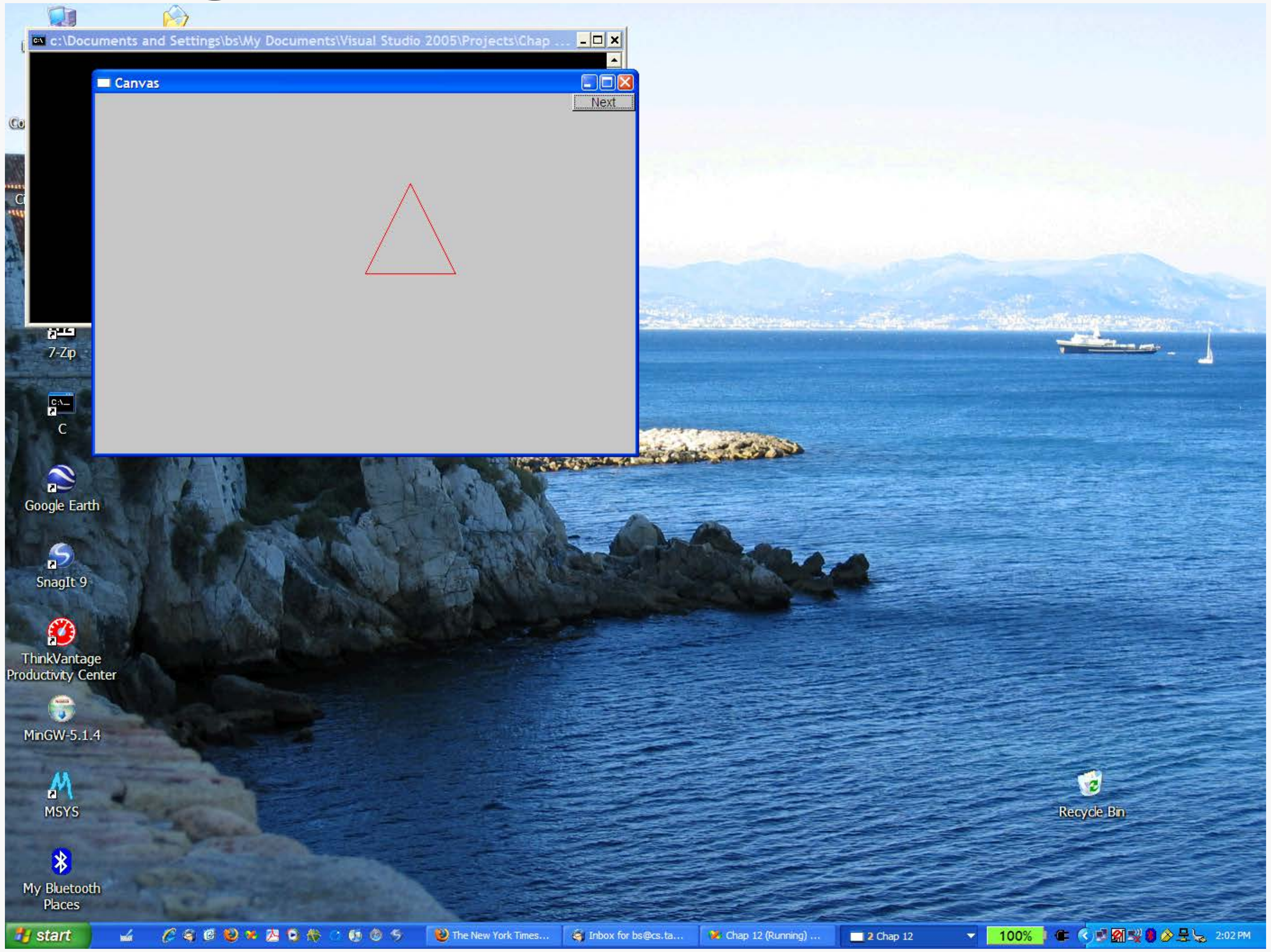


Display model

- An example illustrating the display model

```
int main()
{
    using namespace Graph_lib;   // use our graphics interface library

    Point tl(100,200);                              // a point (obviously)

    Simple_window win(tl,600,400,"Canvas");        // make a simple window

    Polygon poly;                 // make a shape (a polygon, obviously)

    poly.add(Point(300,200));     // add three points to the polygon
    poly.add(Point(350,100));
    poly.add(Point(400,200));

    poly.set_color(Color::red);     // make the polygon red (obviously)

    win.attach(poly);             // connect poly to the window

    win.wait_for_button();        // give control to the display engine
}
```

The resulting screen



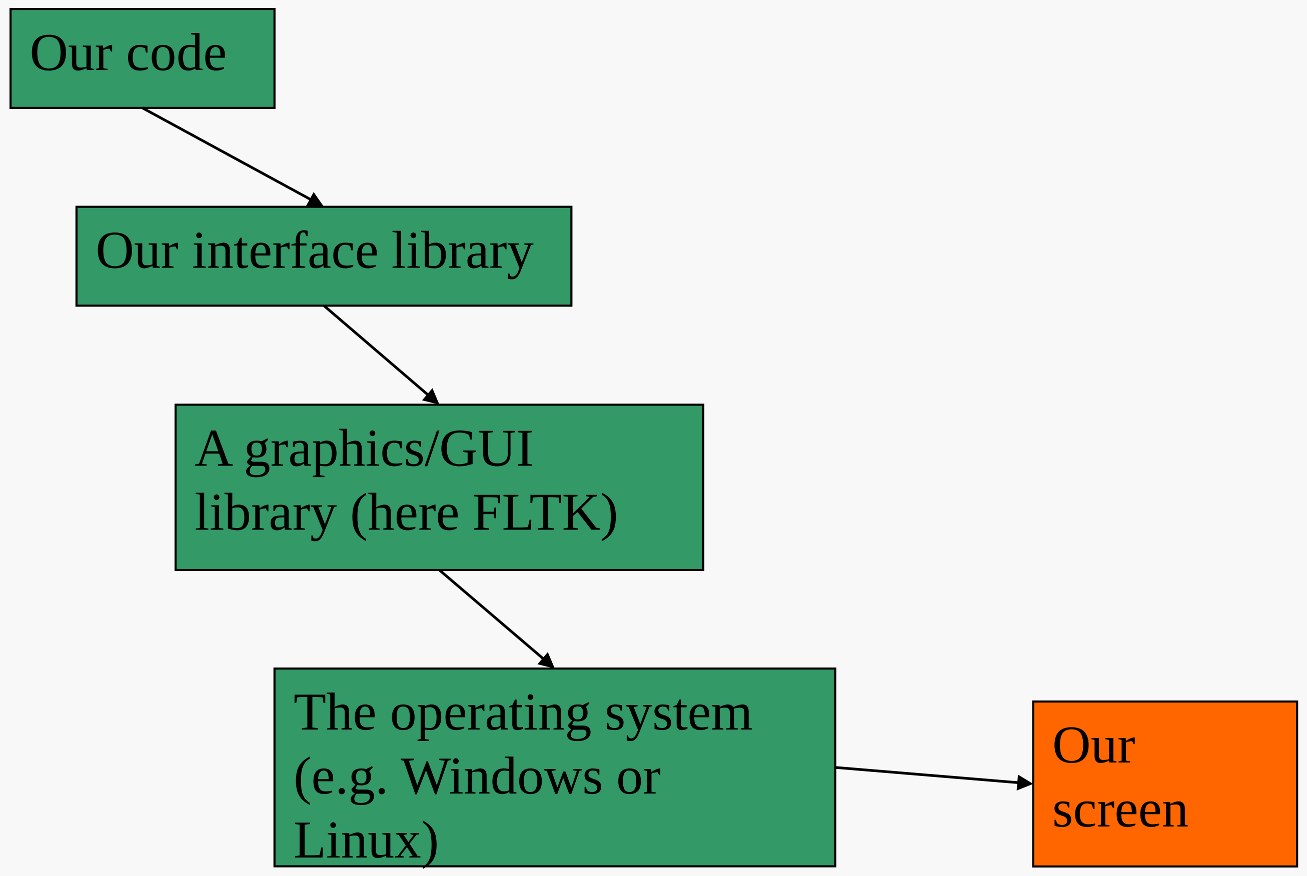
Graphics/GUI libraries

- You’ll be using a few interface classes we wrote
  - Interfacing to a popular GUI toolkit
    - GUI == Graphical User Interface
    - FLTK: www.fltk.org // Fast Light Tool Kit
  - Installation, etc.
    - See piazza.com, Appendix D and ask instructor/friend
      - FLTK
      - Our GUI and graphics classes
      - Project settings
- This model is far simpler than common toolkit interfaces
  - The FLTK (very terse) documentation is 370 pages
  - Our interface library is <20 classes and <500 lines of code
  - You can write a lot of code with these classes
    - And you can build more classes on them

Graphics/GUI libraries (cont.)

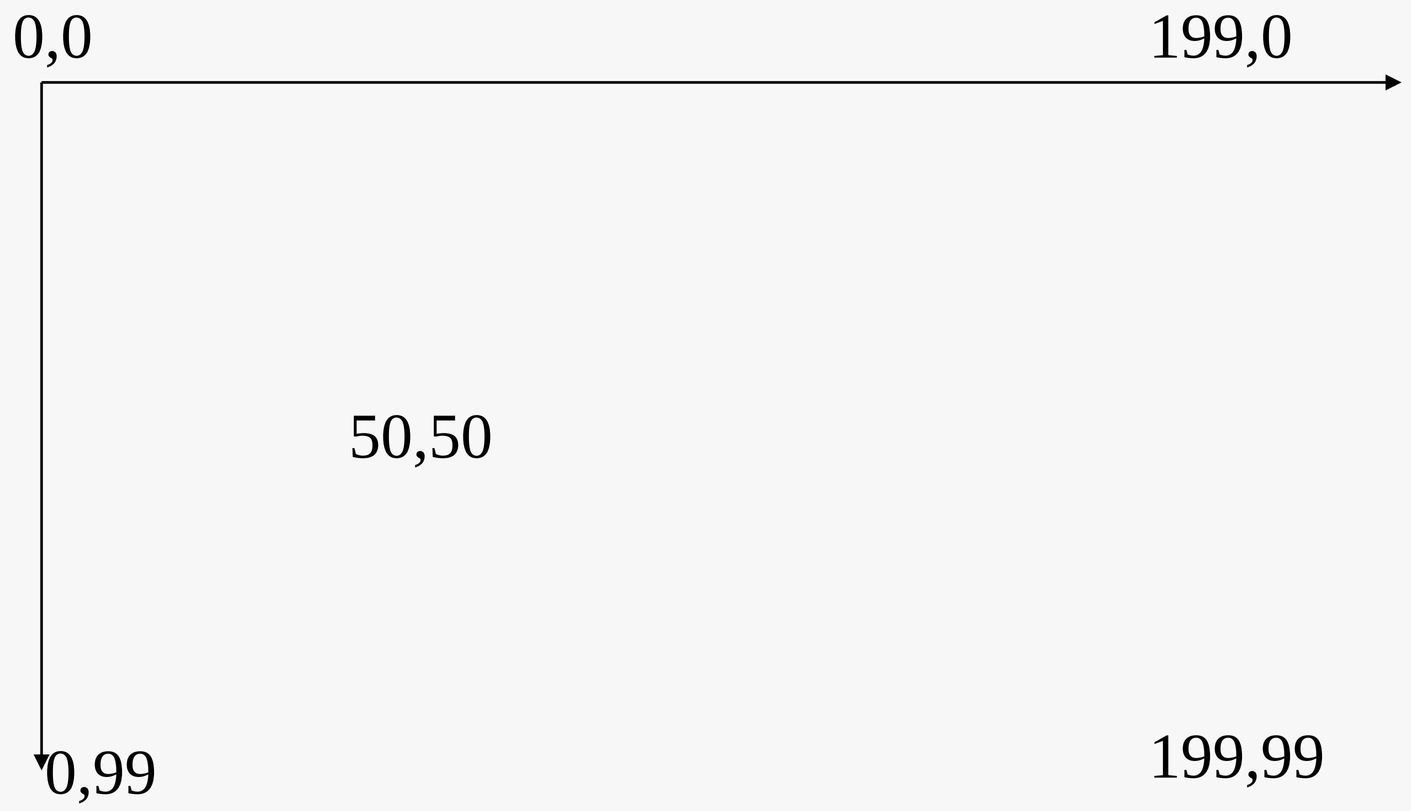
- The code is portable
  - Windows, Unix, Mac, etc.
- This model extends to most common graphics and GUI uses
- The general ideas can be used with any popular GUI toolkit
  - Once you understand the graphics classes you can easily learn any GUI/graphics library
    - Well, relatively easily – these libraries are huge

Graphics/GUI libraries


Our code
Our interface library
A graphics/GUI library (here FLTK)
The operating system (e.g. Windows or Linux)
Our screen

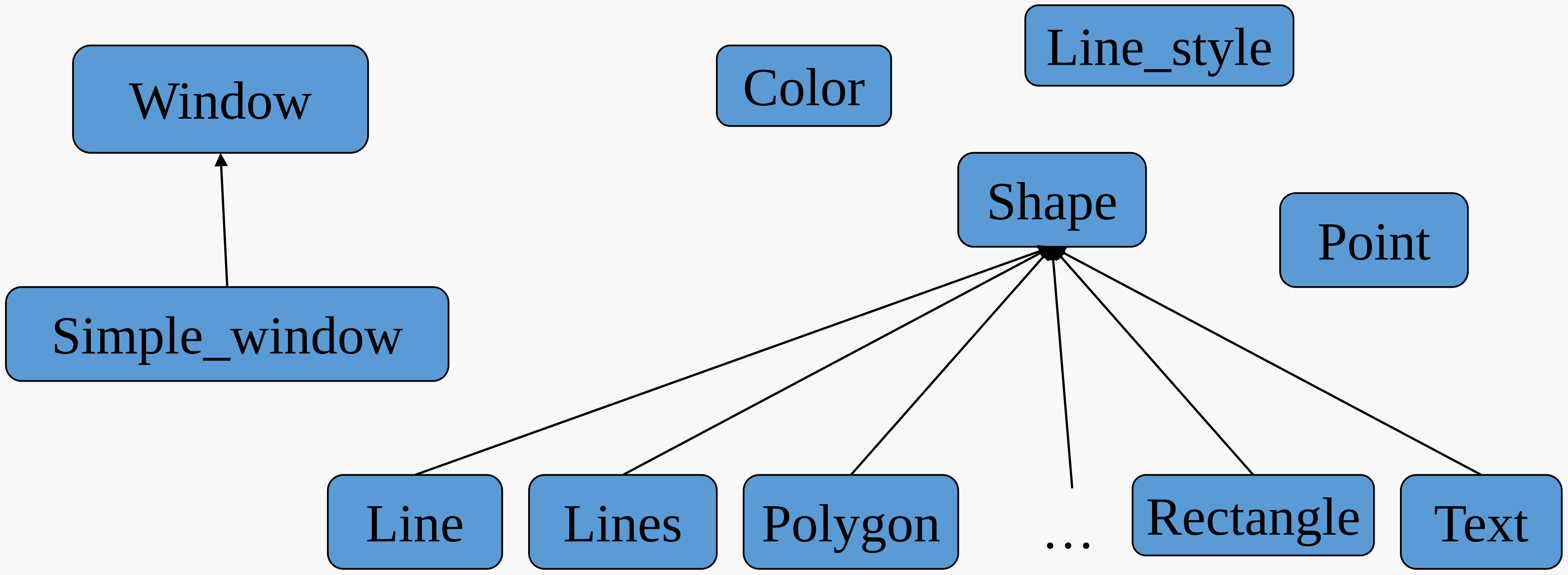
- Often called “a layered architecture”

Coordinates



- Oddly, y-coordinates "grow downwards" // *right, down*
- Coordinates identify pixels in the window on the screen
- You can resize a window (changing **x_max()** and **y_max()**)

Interface classes



- An arrow $\longrightarrow$ means "is a kind of"
- Color, Line_style, and Point are "utility classes" used by the other classes
- Window is our interface to the GUI library (which is our interface to the screen)

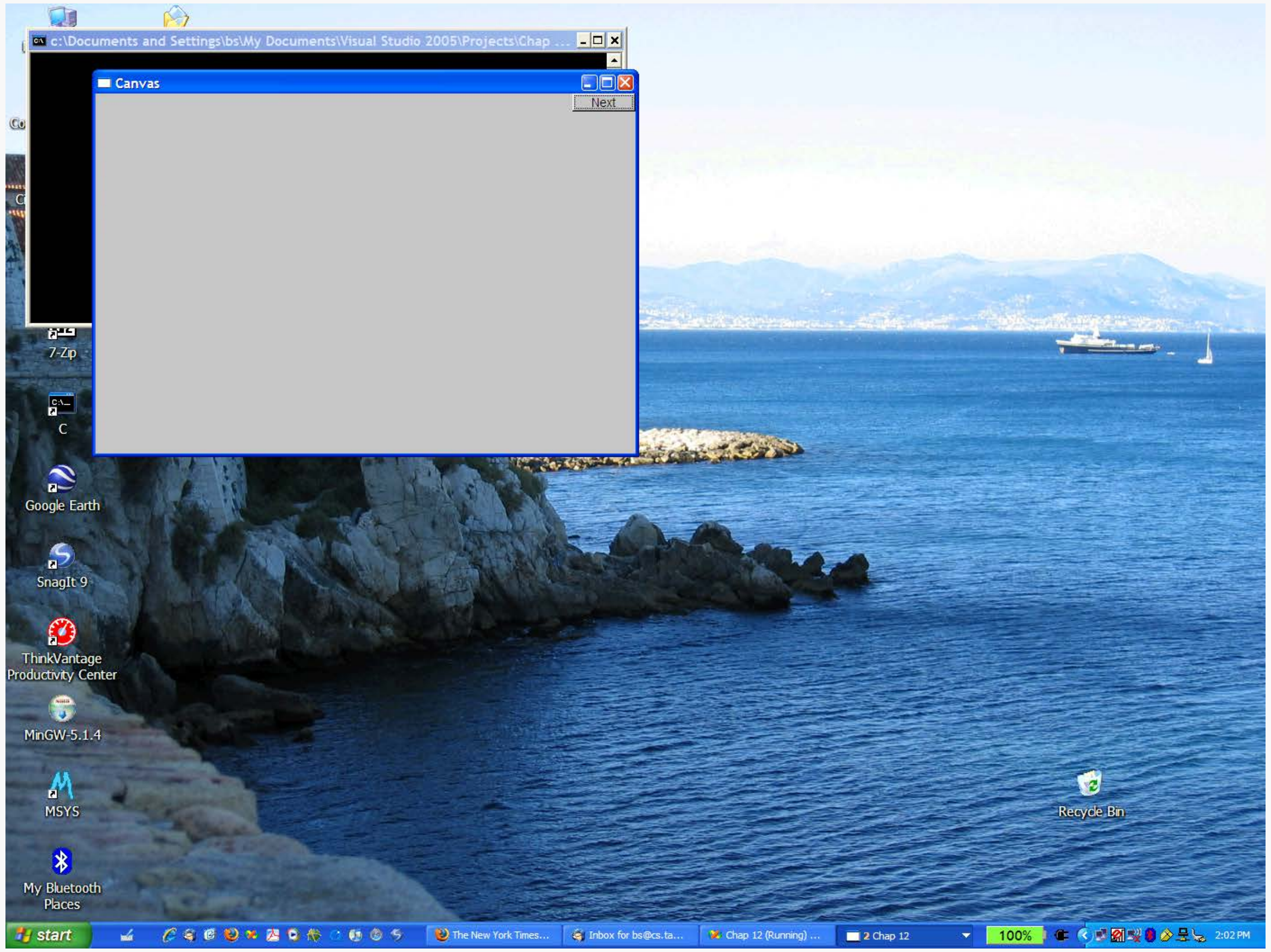
Interface classes

- Current
  - Color, Line_style, Font, Point,
  - Window, Simple_window
  - Shape, Text, Polygon, Line, Lines, Rectangle, …
  - Axis
- Easy to add (for some definition of “easy”)
  - Grid, Block_chart, Pie_chart, etc.
- Later, GUI
  - Button, In_box, Out_box, …

Demo code 1

```
// Getting access to the graphics system (don’t forget to install):
#include "Simple_window.h"     // stuff to deal with your system’s windows
#include "Graph.h"             // graphical shapes

using namespace Graph_lib;     // make names available


// in main():


Simple_window win(Point(100,100),600,400,"Canvas");
            // screen coordinate (100,100) is top left corner of window
            // window size(600 pixels wide by 400 pixels high)
            // title: Canvas
win.wait_for_button(); // Display!
```

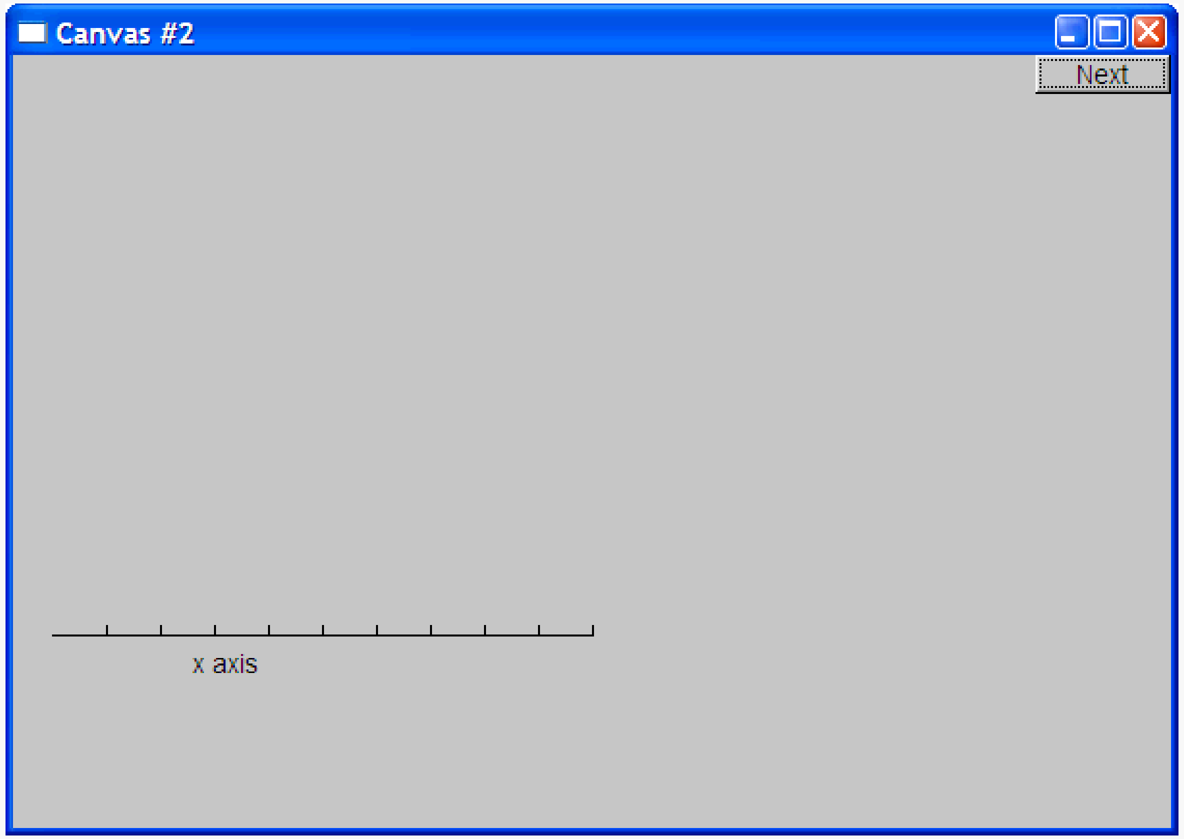
A “blank canvas”



Demo code 2

```
Axis xa(Axis::x, Point(20,300), 280, 10, "x axis");
 // make an Axis
     // an axis is a kind of Shape
     // Axis::x means horizontal
     // starting at (20,300)
     // 280 pixels long
    // 10 "notches" ("tick marks")
    // text "x axis"
win.set_label("Canvas #2");
win.attach(xa);    // attach axis xa to the window
win.wait_for_button();
```

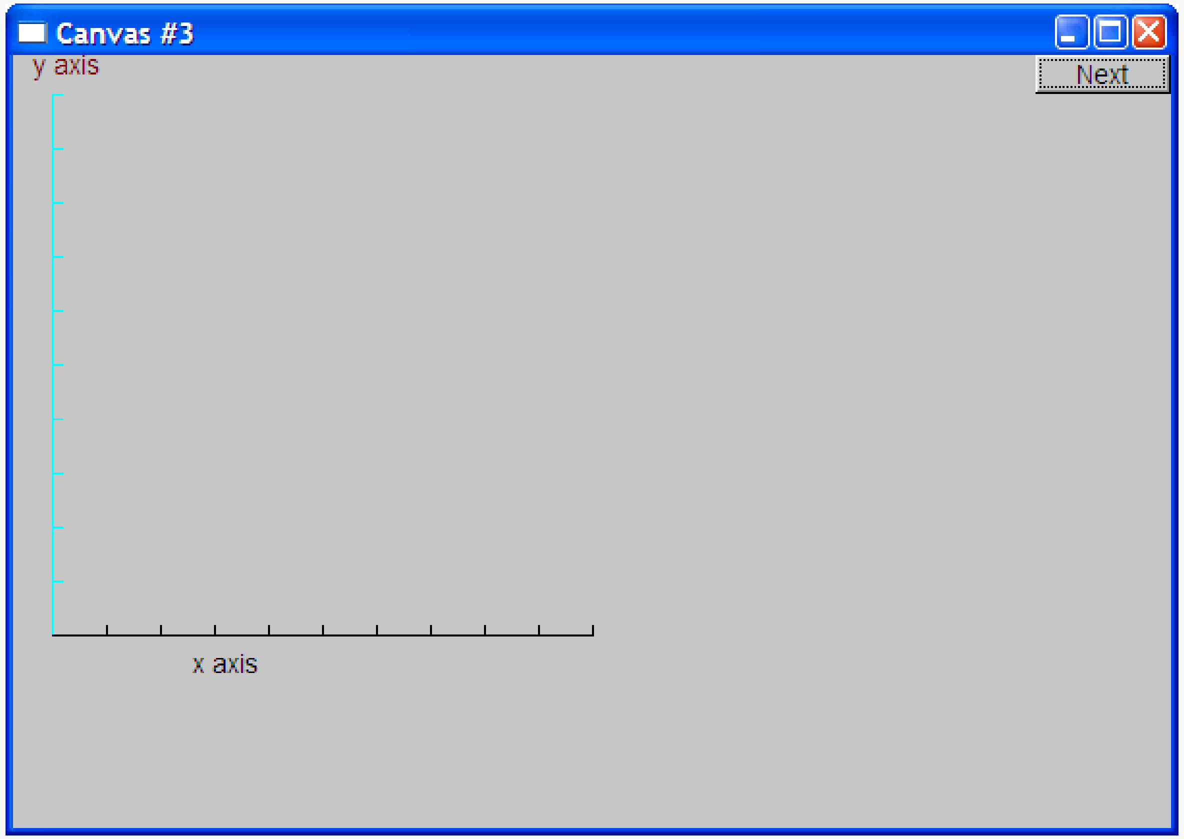
Add an X-axis



Demo code 3

```
win.set_label("Canvas #3");

Axis ya(Axis::y, Point(20,300), 280, 10, "y axis");
ya.set_color(Color::cyan);                // choose a color for the axis
ya.label.set_color(Color::dark_red);      // choose a color for the text

win.attach(ya);
win.wait_for_button();
```

Add a Y-axis (colored)

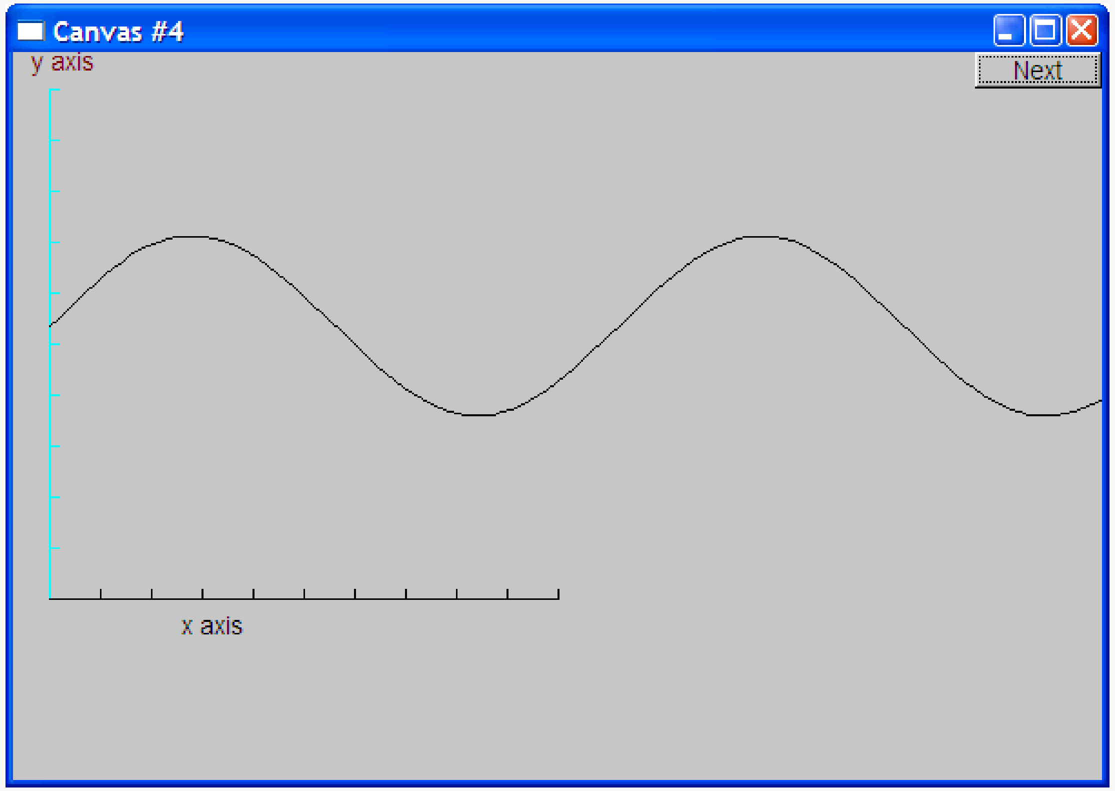


Yes, it's ugly, but this is a programming course, not a graphics design course

Demo code 4

```
win.set_label("Canvas #4");

Function sine(sin,0,100,Point(20,150),1000,50,50);          // sine curve

        // plot sin() in the range [0:100)
        // with (0,0) at (20,150)
        // using 1000 points
        // scale x values *50, scale y values *50

win.attach(sine);
win.wait_for_button();
```

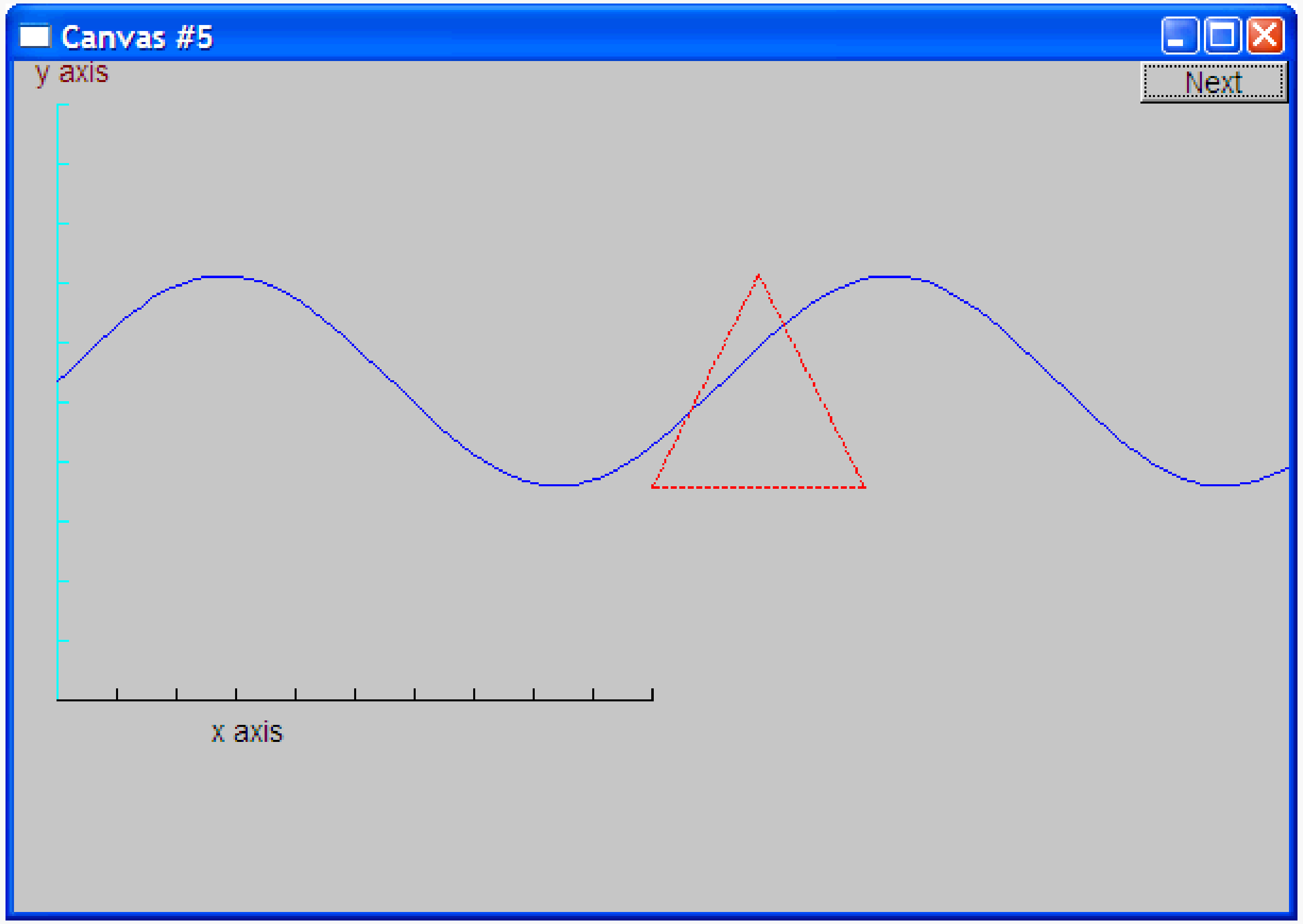
Add a sine curve



Demo code 5

```
win.set_label("Canvas #5");

sine.set_color(Color::blue);        // I changed my mind about sine's color

Polygon poly;                       // make a polygon (a kind of Shape)
poly.add(Point(300,200));           // three points make a triangle
poly.add(Point(350,100));
poly.add(Point(400,200));

poly.set_color(Color::red);         // change the color
poly.set_style(Line_style::dash);            // change the line style

win.attach(poly);
win.wait_for_button();
```

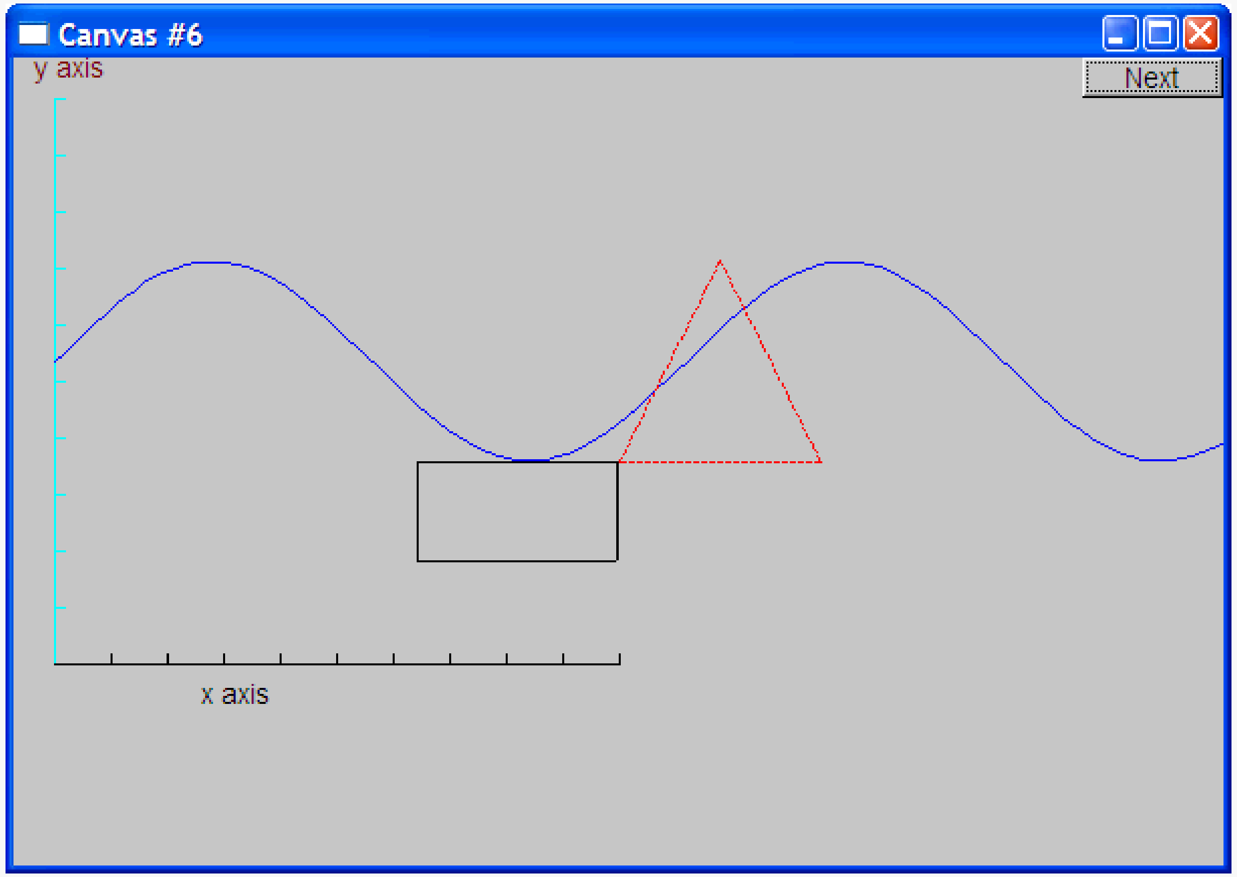
Add a triangle (and color the curve)



Demo code 6

```
win.set_label("Canvas #6");

Rectangle r(Point(200,200), 100, 50);     // top left point, width, height

win.attach(r);
win.wait_for_button();
```

Add a rectangle

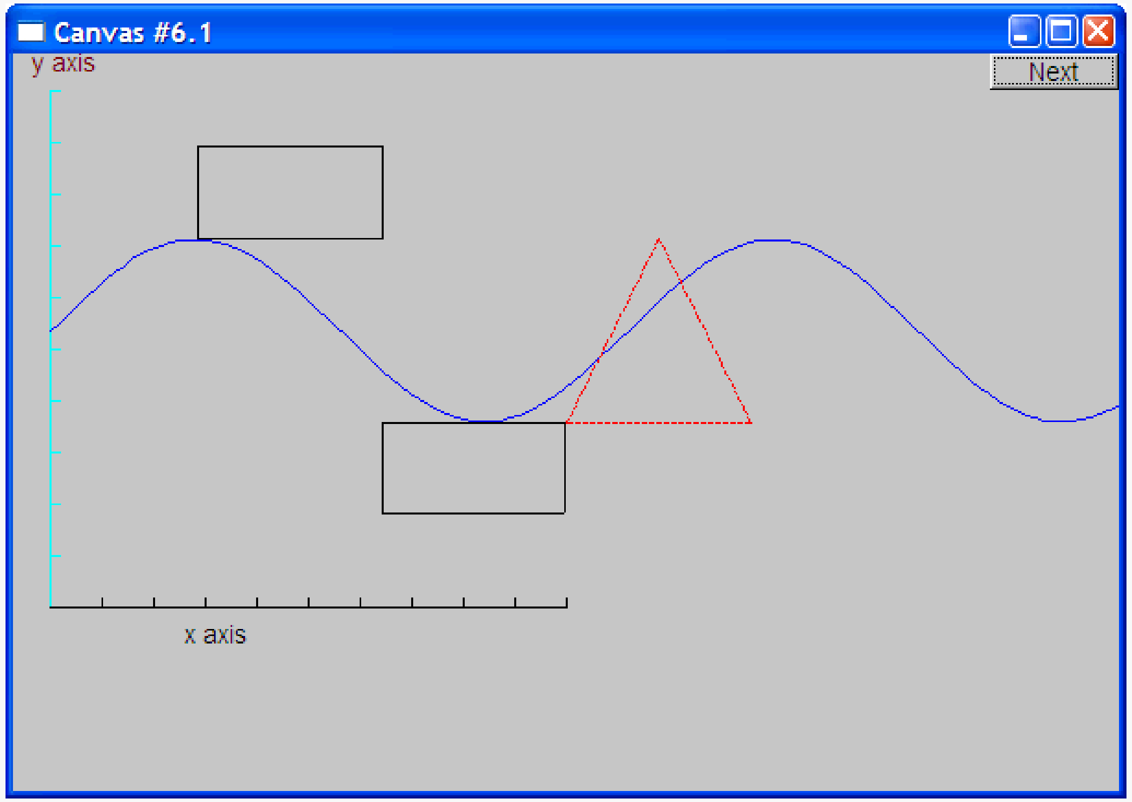


Demo code 6.1

- Add a shape that looks like a rectangle

```
Closed_polyline poly_rect;
poly_rect.add(Point(100,50));
poly_rect.add(Point(200,50));
poly_rect.add(Point(200,100));
poly_rect.add(Point(100,100));

win.set_label("Canvas #6.1");
```

Add a shape that looks like a rectangle



But is it a rectangle?

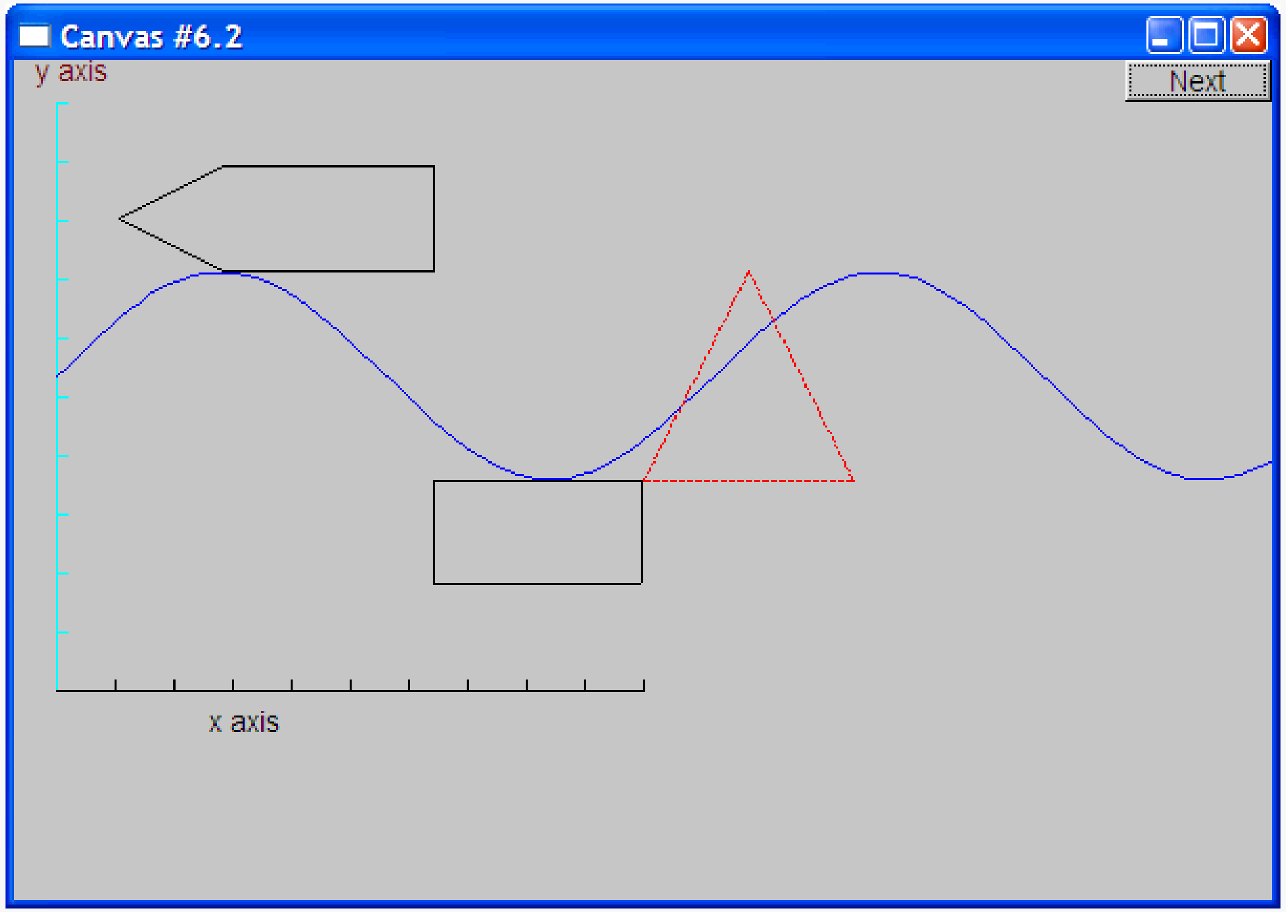
Demo code 6.2

- We can add a point

```
poly_rect.add(Point(50,75); // now poly_rect has 5 points

win.set_label("Canvas #6.2");
```

- “looking like” is not the same as “is”

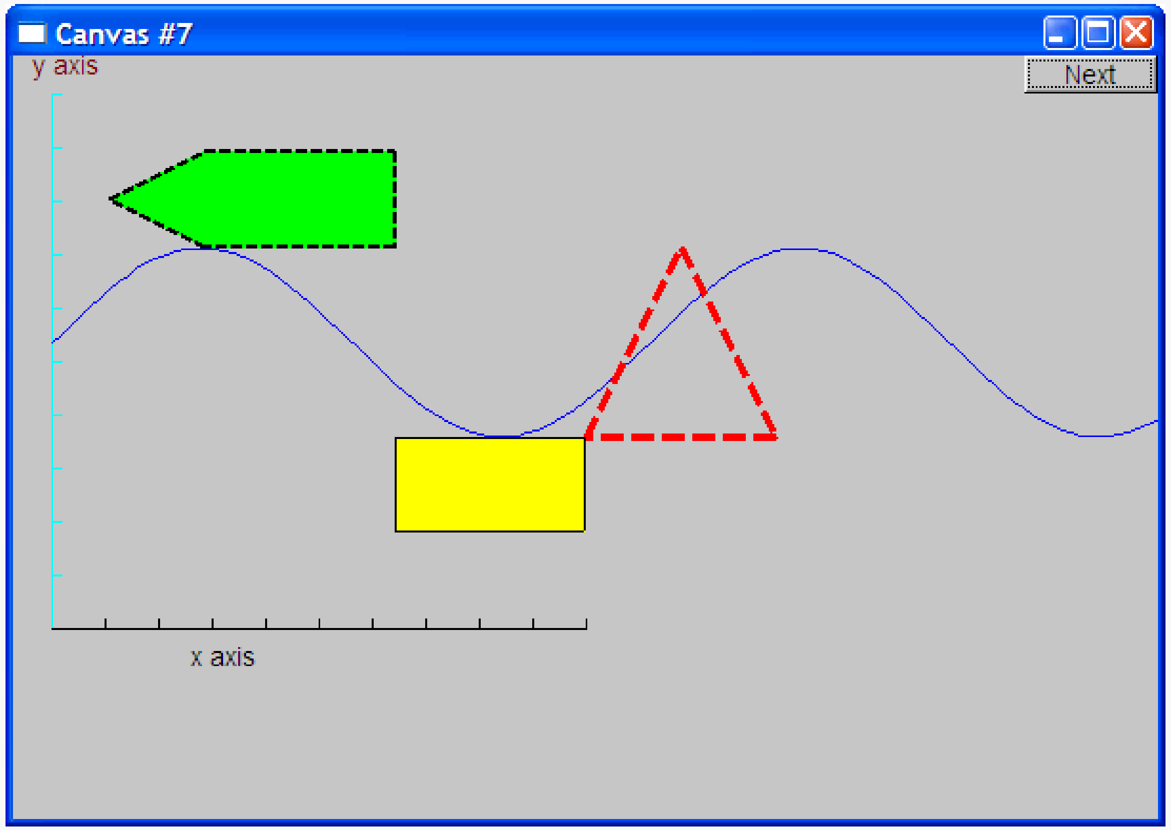
Obviously a polygon



Add fill

```
r.set_fill_color(Color::yellow);     // color the inside of the rectangle

poly.set_style(Line_style(Line_style::dash,4));     // make the triangle fat

poly_rect.set_fill_color(Color::green);
poly_rect.set_style(Line_style(Line_style::dash,2));

win.set_label("Canvas #7");
```

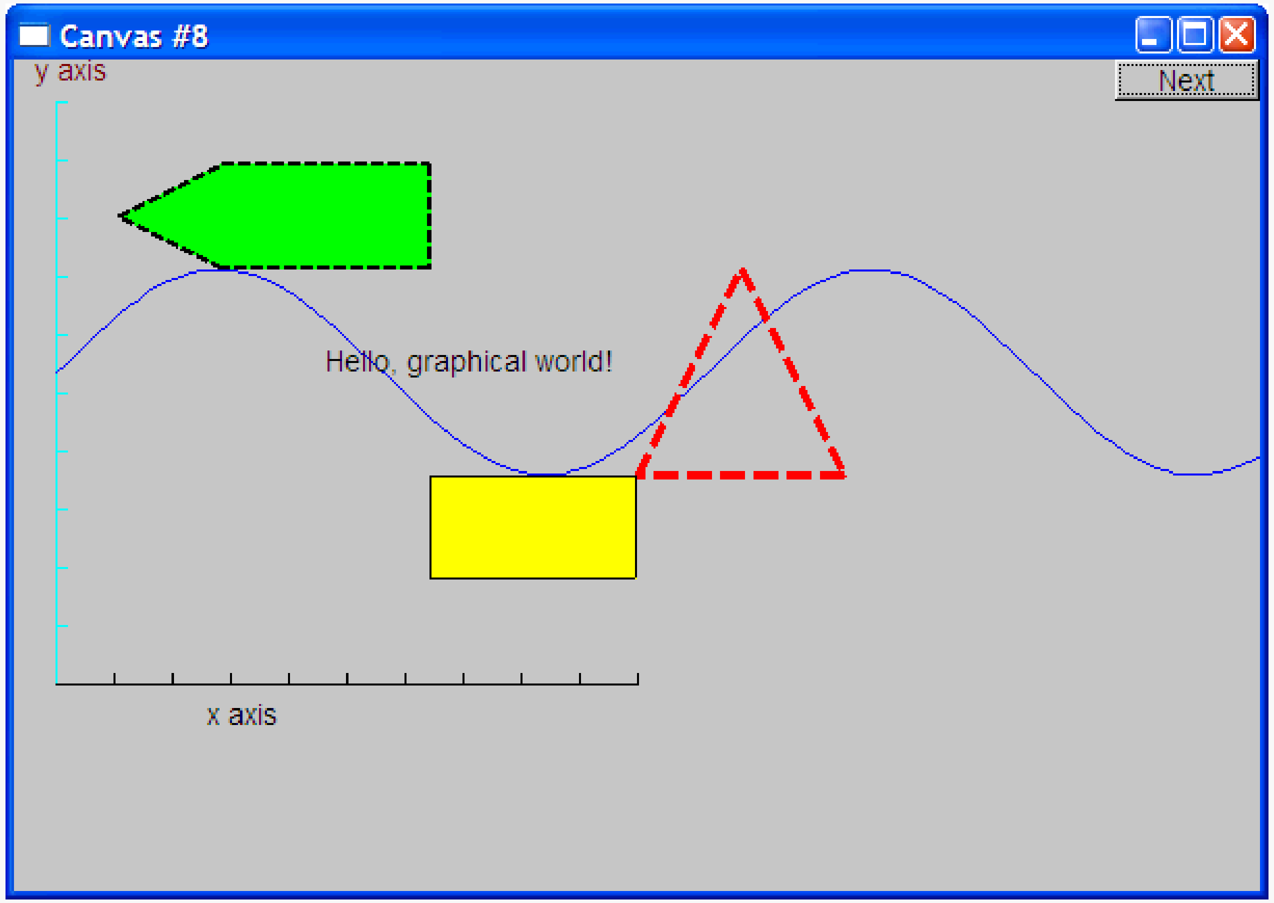
Add fill



Demo Code 8

```
Text t(Point(100,100),"Hello, graphical world!");  // add text
                        ↑          // point is lower left corner on the baseline

win.set_label("Canvas #8");
```

Add text

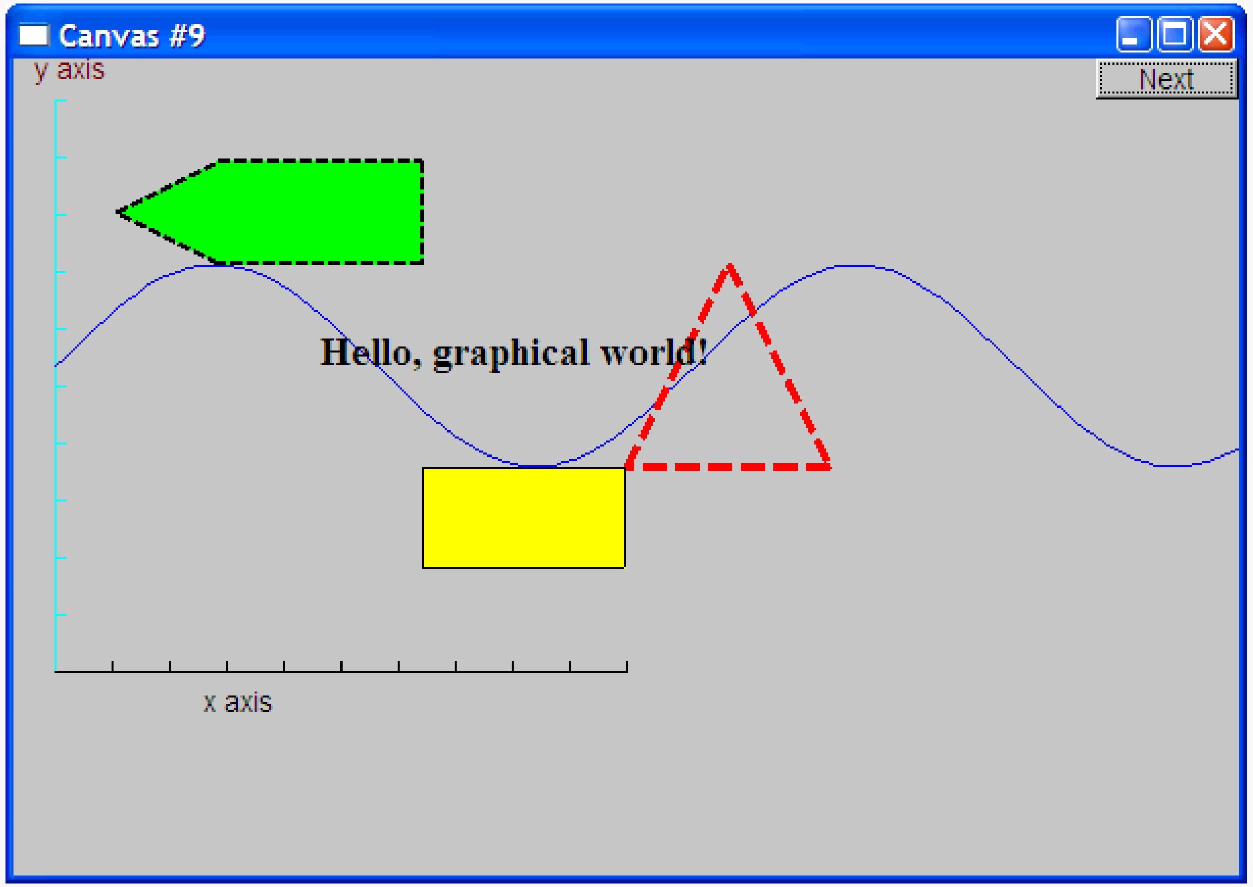


Demo Code 9

- Modify text font and size

```
t.set_font(Font::times_bold);
t.set_font_size(20);  // height in pixels
```

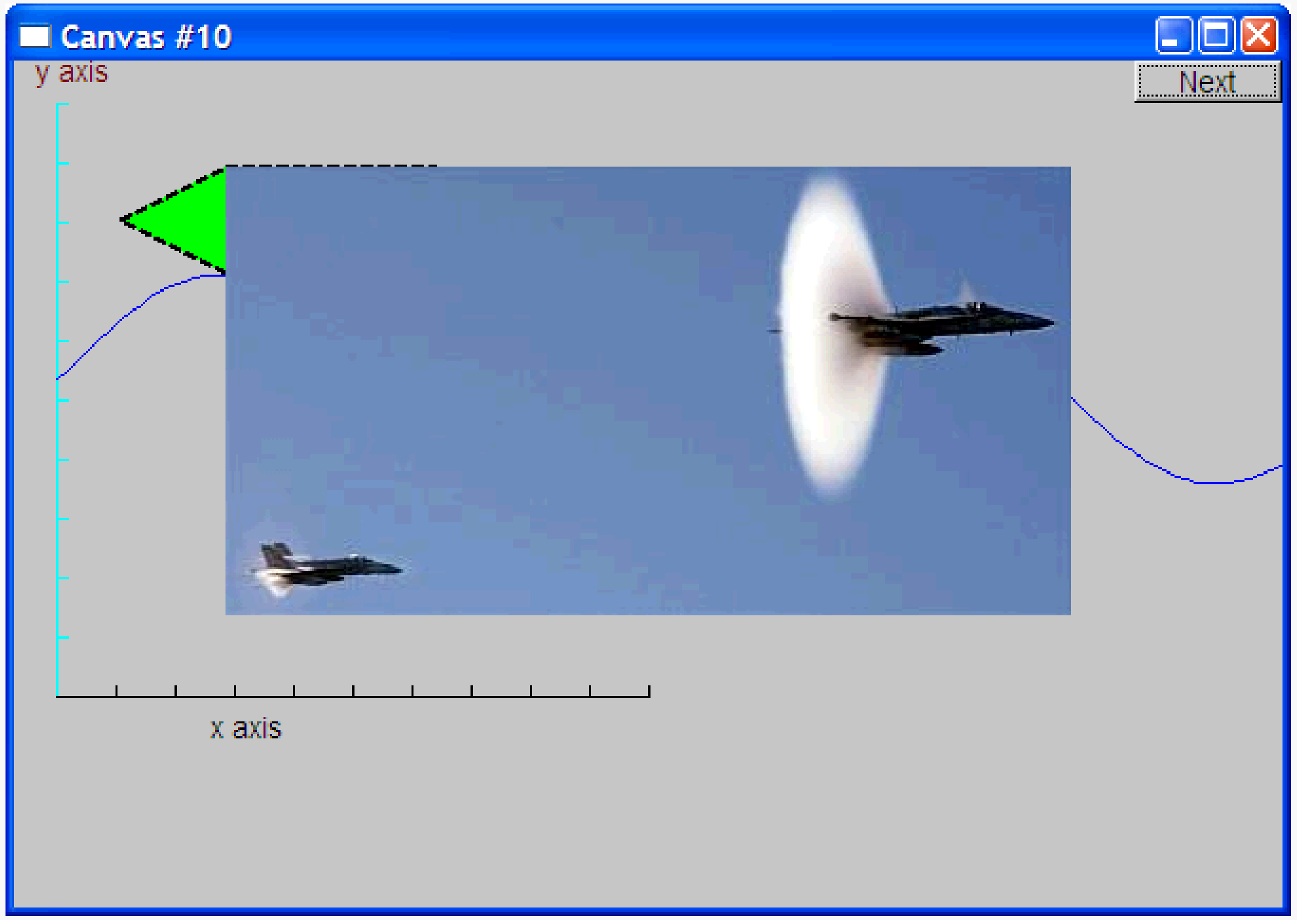
Text font and size



Add an image

```
Image ii(Point(100,50),"image.jpg");        // open an image file
win.attach(ii);
win.set_label("Canvas #10");
```

Add an image

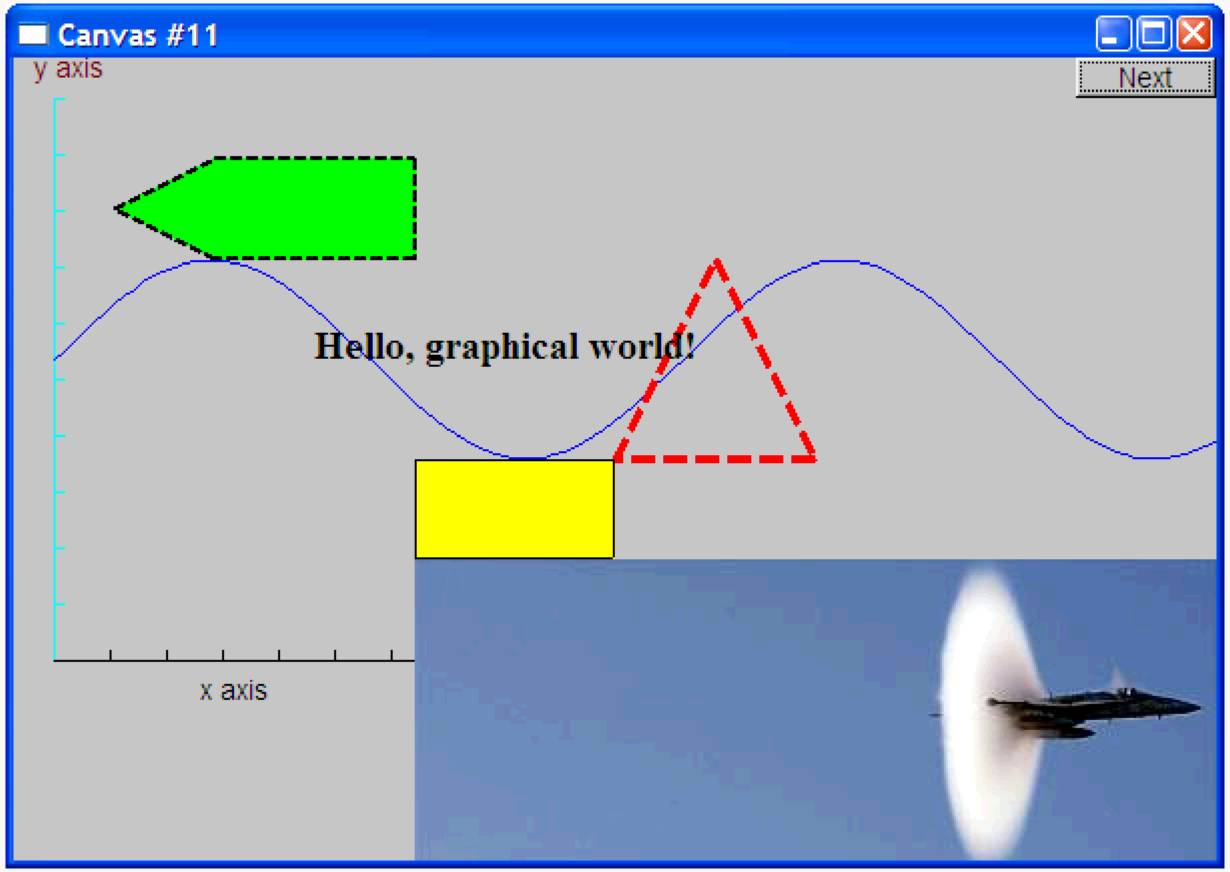


Oops!

- The image obscures the other shapes
  - Move it a bit out of the way

```
ii.move(100,200);    // move 100 pixels to the right (-100 moves left)
                     // move 200 pixels down (-200 moves up)
win.set_label("Canvas #11");
win.wait_for_button();
```

Move the image

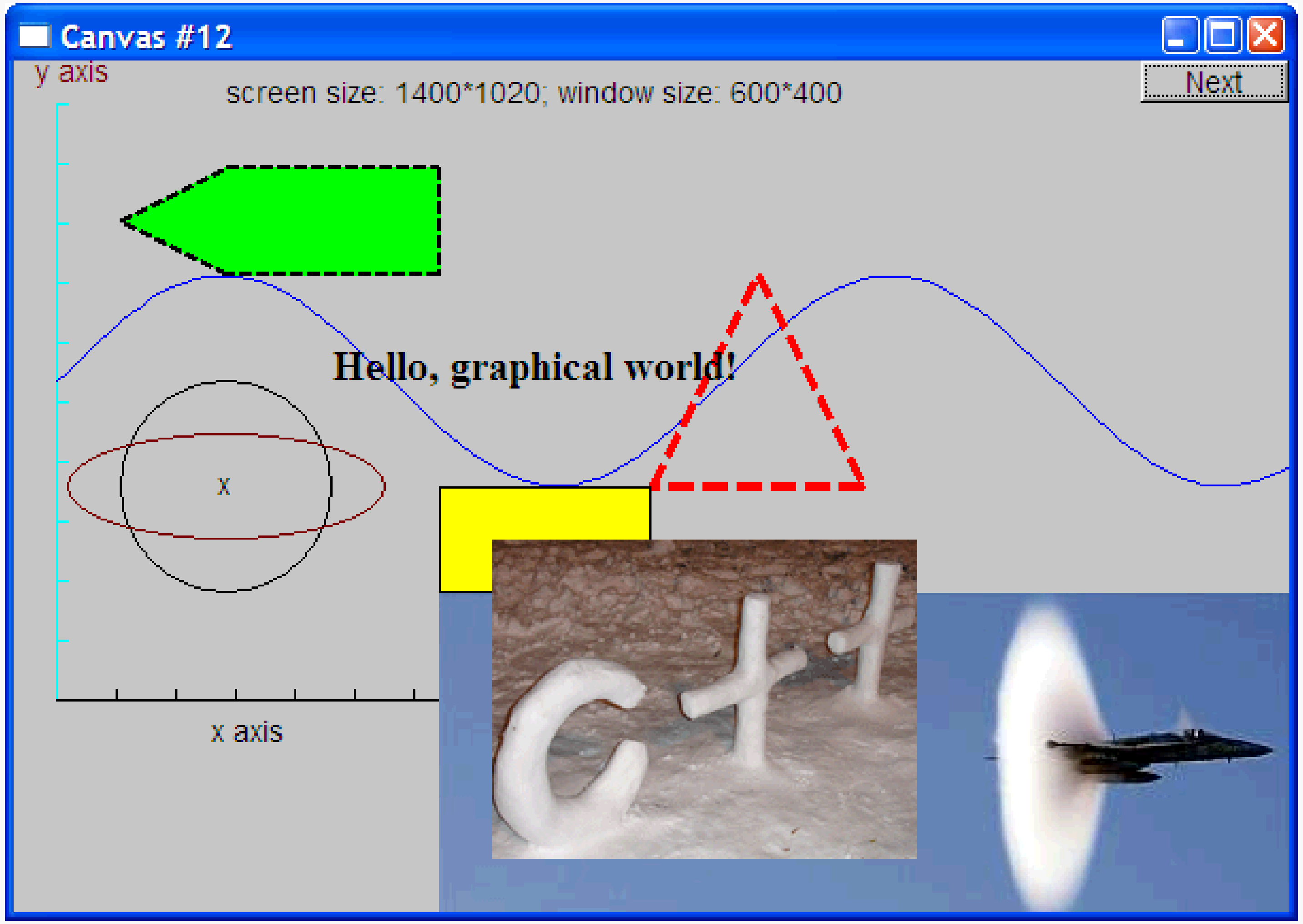


Note how the parts of a shape that don't fit in the window are "clipped" away

Demo Code 12

```
Circle c(Point(100,200),50);           // center, radius

Ellipse e(Point(100,200), 75,25);     // center, horizontal radius, vertical radius
e.set_color(Color::dark_red);

Mark m(Point(100,200),'x');

ostringstream oss;
oss << "screen size: " << x_max() << "*" << y_max()
		<< "; window size: " << win.x_max() << "*" << win.y_max();
Text sizes(Point(100,20),oss.str());

Image cal(Point(225,225), "snow_cpp.gif"); // 320*240 pixel gif
cal.set_mask(Point(40,40),200,150);                    // display center of image


win.set_label("Canvas #12");
win.wait_for_button();
```

Add shapes, more text



screen size: 1400*1020; window size: 600*400

Boiler plate

```
#include "Graph.h"                        // header for graphs
#include “Simple_window.h"                // header containing window interface

int main ()
try
{
    // the  main part of your code
}
catch(exception& e) {
    cerr << "exception: " << e.what() << '\n';
    return 1;
}
catch (...) {
    cerr << "Some exception\n";
    return 2;
}
```

Primitives and algorithms

- The demo shows the use of library primitives
  - Just the primitives
  - Just the use
- Typically what we display is the result of
  - an algorithm
  - reading data

- Next lectures
  - 13: Graphics Classes
  - 14: Graphics Class Design
  - 15: Graphing Functions and Data
  - 16: Graphical User Interfaces