Week 2

Game Loop Programming

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Objectives

- Explore an example game loop
- Review and apply the concepts of frames, frame rates and fixed time steps
- Create and display sprites to the game window

- A friend function of a class is defined outside that class' scope but it has the right to access all private and protected members of the class.

```cpp
class Box {
double width;

public:
double length;
friend void printWidth(Box box);
void setWidth(double wid);
};
```

- Class myClass {}
- the compiler provides you a default zero argument constructor, along with a destructor, a copy constructor, and a copy assignment operator.

```cpp
#include <iostream>
using namespace std;
class complexNumbers {
double real, img;
public:
//default constructor
complexNumbers() : real(0), img(0) { }

//copy constructor
complexNumbers(const complexNumbers& c) { real = c.real; img = c.img; }

//implicit conversion
complexNumbers(double r, double i = 0.0) { real = r; img = i; }


//friend function
friend void display(complexNumbers cx);
};
void display(complexNumbers cx) {
cout << "Real Part: " << cx.real << " Imag Part: " << cx.img << endl;
}
int main() {
complexNumbers one(1);
complexNumbers five = 5;   //copy assignment operator
display(one);
display(five);
display(300);   //⬅ Implicit conversion
return 0;
}
```
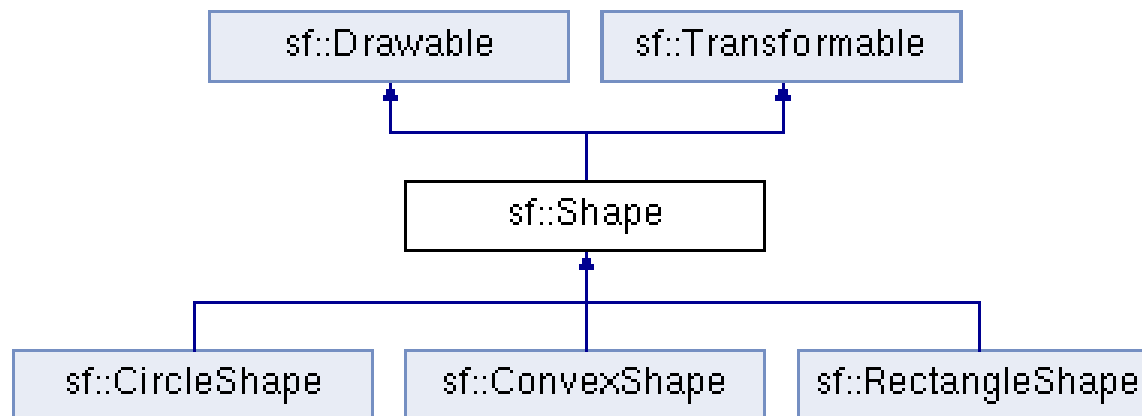
Explicit constructor

- The explicit function specifier controls unwanted implicit type conversions. It can only be used in declarations of constructors within a class declaration.

```
explicit complexNumbers2(double r, double i = 0.0)
{ real = r; img = i; }
complexNumbers2 one(1);
//complexNumbers2 five = 5; //not allowed using explicit
display2(one);
//display2(300);  // Implicit conversion not allowed
```
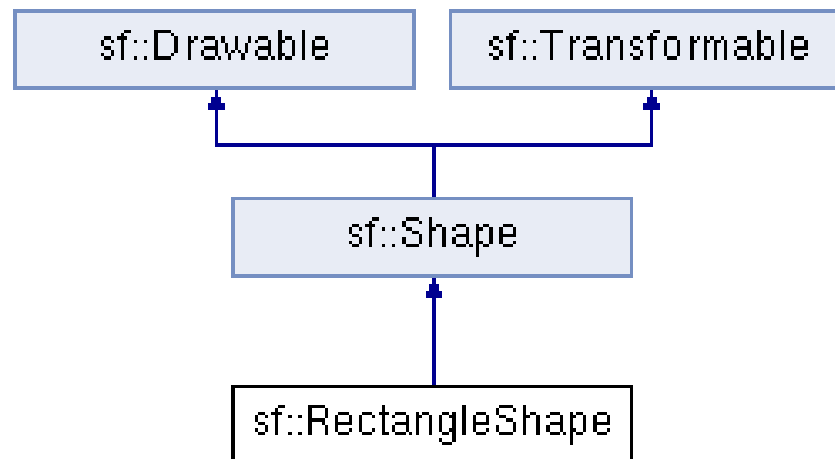
- Base class (abstract) for textured shapes with outline

- RectangleShape (const Vector2f &size=Vector2f(0, 0))

- Creates a convex polygon.

```
sf::ConvexShape mPolygon;

mPolygon.setPointCount(3);
mPolygon.setPoint(0, sf::Vector2f(0, 0));
mPolygon.setPoint(1, sf::Vector2f(0, 50));
mPolygon.setPoint(2, sf::Vector2f(50, 50));
mPolygon.setFillColor(sf::Color::Magenta);
mPolygon.setOutlineColor(sf::Color::Red);
mPolygon.setOutlineThickness(5);
mPolygon.setPosition(400, 400);
```

Sf::Image

- ## Class for loading, manipulating and saving images.

```cpp
sf::Image mImage;

mImage.create(20, 20, sf::Color::Yellow);
sf::Color color = mIcon.getPixel(0, 0);
color.a = 0; //make the top-left pixel transparent
color.r = 0;    //set the r = 0 (rgb) from the color
mIcon.setPixel(0, 0, color);
// Save the image to a file
if (!mImage.saveToFile("Media/Textures/result.png"))
cout << "Cannot save my image to Textures folder " <<
endl;
```

How to set an Icon for the window

```
sf::Image mIcon;
mIcon.loadFromFile("Media/Textures/icon.png");
mWindow.setIcon(mIcon.getSize().x, mIcon.getSize().y,
mIcon.getPixelsPtr());
```
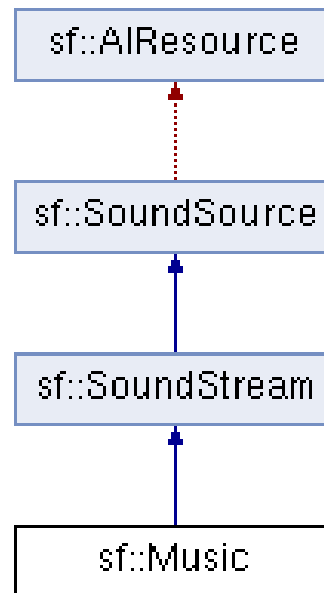
- Create a graphical text to display

```
sf::Font mFont;
sf::Text mText;
if
(!mFont.loadFromFile("Media/Sansation.ttf"))
return;


mText.setString("Hello SFML");
mText.setFont(mFont);
mText.setPosition(5.f, 5.f);
mText.setCharacterSize(50);
mText.setFillColor(sf::Color::Black);
```

Sf::Music

- Streams music played from an audio file

```
sf::AlResource
      ↑
sf::SoundSource
      ↑
sf::SoundStream
      ↑
sf::Music
```

- Streamed music played from an audio file
- Musics are sounds that are streamed rather than completely loaded in memory
- A music is played in its own thread in order not block the rest of the program
- Supported audio formats: ogg, wav, flac, aiff, au, raw, paf, svx, nist, voc, ircam, w64, mat4, mat5, pvf, htk, sds, avr, sd2, caf, wve, mpc2k, rf64

```cpp
#include <SFML/Audio.hpp>
sf::Music mMusic;
mMusic.openFromFile("Media/Textures/nice_music.ogg");
//change some parameters
mMusic.setPosition(0, 1, 10); //change its 3D position
mMusic.setPitch(2); //increase the pitch
mMusic.setVolume(50); //reduce the volume
mMusic.setLoop(true); //make it loop
mMusic.setAttenuation(100);
mMusic.play();
```

- The run() function you saw in the example from last week, and below, is known as the main loop or game loop

```
void Game::run()
{
  while (mWindow.isOpen())
  {
    processEvents();
    update();
    render();
  }
}
```
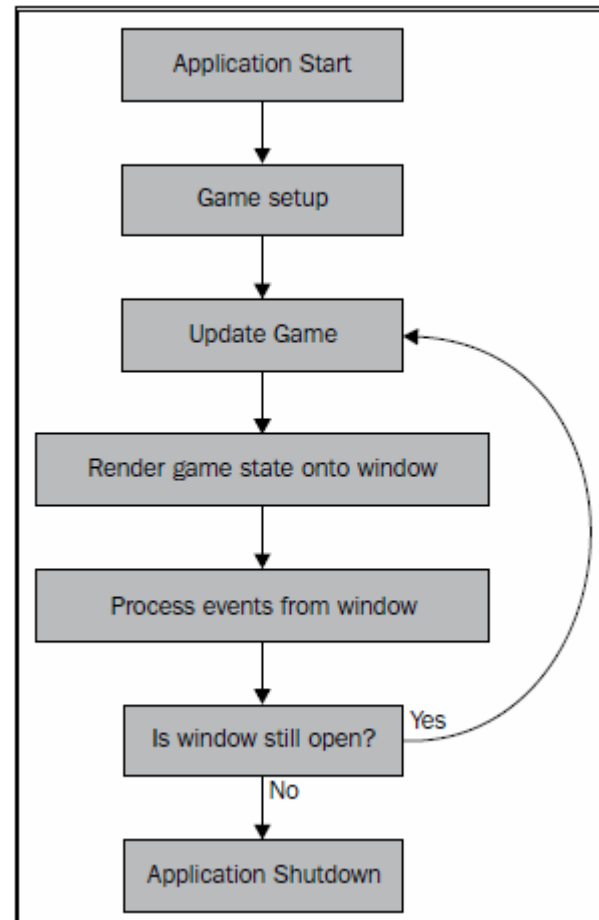
- It processes all the components in the game and continues to do so until the application is terminated
- The processing of events, updating of all game assets and then rendering them to the destination output is a standard loop for games

Game Loop (cont'd.)

- It processes all the components in the game and continues to do so until the application is terminated
- The processing of events, updating of all game assets and then rendering them to the destination output is a standard loop for games
- You've heard the term **frame** or **tick** before, and that is what we call an iteration of the loop

- The flowchart to the right illustrates the logic and different processes of the game, including the main loop

Application Start → Game setup → Update Game → Render game state onto window → Process events from window → Is window still open? — Yes → (back to Update Game); No → Application Shutdown

Events

- Events can be user-generated such as mouse clicks or movement or keyboard presses
- They can also be generated by the assets in the game, such as when an enemy spots the player
- We don't have any events in our example yet, so let's create some!

- How 'bout moving that circle with the keyboard?

- For events in SFML, we use the `sf::Event` object
- We're going to use two events for this example:

  `sf::Event::KeyPressed` and `sf::Event::KeyReleased`

processEvents()

```cpp
void Game::processEvents()
{
    sf::Event event;
    while (mWindow.pollEvent(event))
    {
        switch (event.type)
        {
            case sf::Event::KeyPressed:
                handlePlayerInput(event.key.code, true);
                break;
            case sf::Event::KeyReleased:
                handlePlayerInput(event.key.code, false);
                break;
            case sf::Event::Closed:
                mWindow.close();
                break;
        }
    }
}
```

```
void Game::handlePlayerInput(sf::Keyboard::Key key, bool isPressed)
{
        if (key == sf::Keyboard::W)
          mIsMovingUp = isPressed;
        else if (key == sf::Keyboard::S)
          mIsMovingDown = isPressed;
        else if (key == sf::Keyboard::A)
          mIsMovingLeft = isPressed;
        else if (key == sf::Keyboard::D)
          mIsMovingRight = isPressed;
}
```

New update()

```cpp
void Game::update()
{
    sf::Vector2f movement(0.f, 0.f);
    if (mIsMovingUp)
        movement.y -= 1.f;
    if (mIsMovingDown)
        movement.y += 1.f;
    if (mIsMovingLeft)
        movement.x -= 1.f;
    if (mIsMovingRight)
        movement.x += 1.f;

    mPlayer.move(movement);
}
```

```
if (sf::Mouse::isButtonPressed(sf::Mouse::Left))
{
sf::Vector2i mousePosition =
sf::Mouse::getPosition(mWindow);
mPlayer.setPosition((float)mousePosition.x,
(float)mousePosition.y);
}
```

Vector Object

- SFML's Vector object is instantiated as:
  ```
  sf::Vector2<float>
  ```
- We use the typedef for variable declarations, which is as follows:
  ```
  sf::Vector2f myVector(0.f, 0.f);
  ```

- As you would expect, there are many common operations in the Vector class that we can access through a Vector object

- In games, vectors can represent coordinates or a direction to move
- The diagram below represents a vector(2,3) and it could be a translation of 2 units to the right and 3 down:
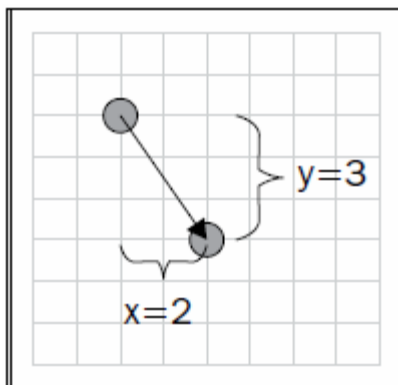
Frame-Independence

- You might remember from Unity that we were able to move an object a certain number of units per second

  - We multiplied the speed by Time.deltaTime

- We can do this in SFML too, so that the player's movement isn't dependent on the framerate – or number of times the update runs per second

- Well, we're still relying on the framerate, but the movement is spread out evenly over the frames

- So let's have a look at our new update function and see what's new…

```cpp
void Game::update(sf::Time deltaTime)
{
sf::Vector2f movement(0.f, 0.f);
if (mIsMovingUp)
movement.y -= PlayerSpeed;
if (mIsMovingDown)
movement.y += PlayerSpeed;
if (mIsMovingLeft)
movement.x -= PlayerSpeed;
if (mIsMovingRight)
movement.x += PlayerSpeed;
mPlayer.move(movement * deltaTime.asSeconds());
}
```

Measuring Frames

- We can measure the time each frame takes in order to figure out `deltaTime`
- We use the `sf::Clock` class
- Sf::Clock has only two methods: getElapsedTime() and restart(). Both returns the elapsed time since the clock was started and then it resets the clock to zero. getElapsedTime() can be called without calling restart()

```
sf::Clock clock;
sf::Time time = clock.getElapsedTime();
float seconds = time.asSeconds();
sf::Int32 milliseconds = time.asMilliseconds();
sf::Int64 microseconds = time.asMicroseconds();
time = clock.restart();
```

```
void Game::run()
{

sf::Clock clock;
while (mWindow.isOpen())
{
sf::Time deltaTime = clock.restart();
processEvents();
update(deltaTime);
render();
}
}
```

Fixed Time Step

- Time based on a system function such as a while loop will never be constant

  - We saw this way back with HTML5 and its highly-varying frame rate

  - Unity too!

- Fortunately we can create fixed time execution using a counter and a check

  - The while loop is definitely going to execute fast enough to serve as very small time increments added to our counter variable

```
void Game::run()
{
    sf::Clock clock;
    sf::Time timeSinceLastUpdate = sf::Time::Zero;
    while (mWindow.isOpen())
    {
        processEvents();
        timeSinceLastUpdate += clock.restart();
        while (timeSinceLastUpdate > TimePerFrame)
        {
            timeSinceLastUpdate -= TimePerFrame;
            processEvents();
            update(TimePerFrame);
        }
        render();
    }
}
```

- If you want to read more on this topic, you can read the article at the following address:

  - http://gafferongames.com/game-physics/fix-your-timestep

```
sf::Texture texture;
if (!texture.loadFromFile("path/to/file.png"))
{
  // Handle loading error
}
sf::Sprite sprite(texture);
sprite.setPosition(100.f, 100.f);
window.clear();
window.draw(sprite);
window.display();
```

Rendering

- Rendering is the process of drawing your assets to the screen
- Ideally, we'd only want our assets being drawn if they were updated somehow in the program
  - Would save on performance
- However, *real-time rendering* just draws to the screen as fast as possible

- Have you ever wondered why there is an FPS count in games? Like 30 or 60
- It's because the end user can't see blindingly-fast updates so the frame rate is limited to allow the processor to perform other tasks

- *Double buffering* is a technique of rendering that uses two virtual windows or screens, called buffers

  - Front and back buffers
- The front buffer is what the user sees
- The back buffer is what's going to be drawn next frame – will become the front buffer

```
// Game.hpp
class Game
{
  public:
    Game();

    ...

  private:
    sf::Texture mTexture;

    sf::Sprite mPlayer;

    ...
};
```

```cpp
// Game.cpp
Game::Game()
: ...
, mTexture()
, mPlayer()
{
  if (!mTexture.loadFromFile("Media/Textures/Eagle.png"))
  {
    // Handle loading error
  }

  mPlayer.setTexture(mTexture);
  mPlayer.setPosition(100.f, 100.f);
}
```

- Zoom
  - Press **Ctrl+Mouse** wheel to increase and decrease the font size
- Box Selector
  - Select rectangular region, type a line, and have that line repeated for every line part of the region
    - Hold **Alt** while using mouse to make vertical section
    - Start typing…typed line appears on every line in region
- Generate from Usage
  - Type method invocation without first creating method
    - **Ctrl** + dot (.) automatically generates heading

- When Visual Studio is launched, Start Page is displayed
  - Checkbox in extreme left corner – **Show page at startup**
    - Check/uncheck **Close page after project load** to add/remove Start page tab from development environment
- Pin a project so it is always there
  - Pushpin is revealed when you move mouse over Recent projects area
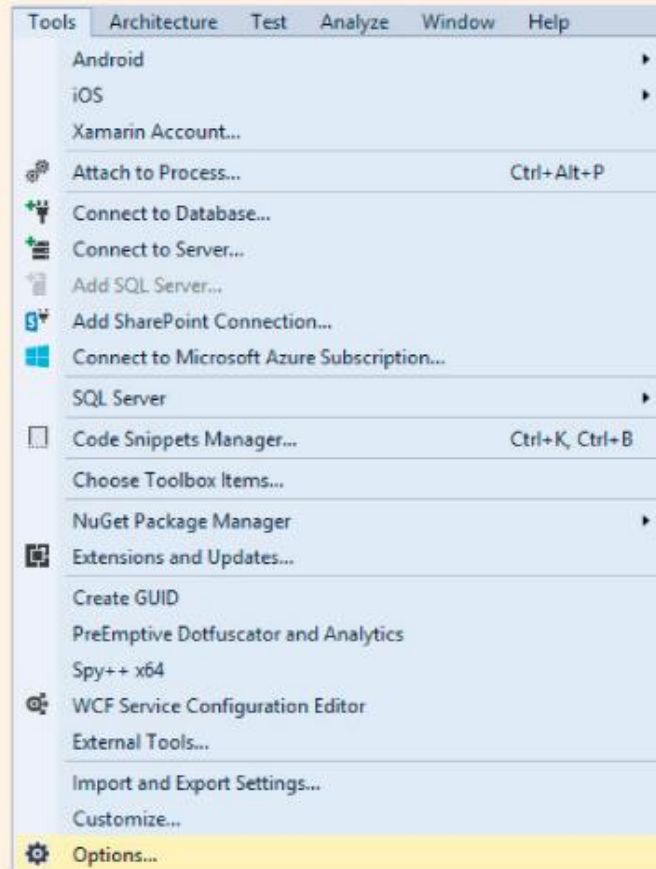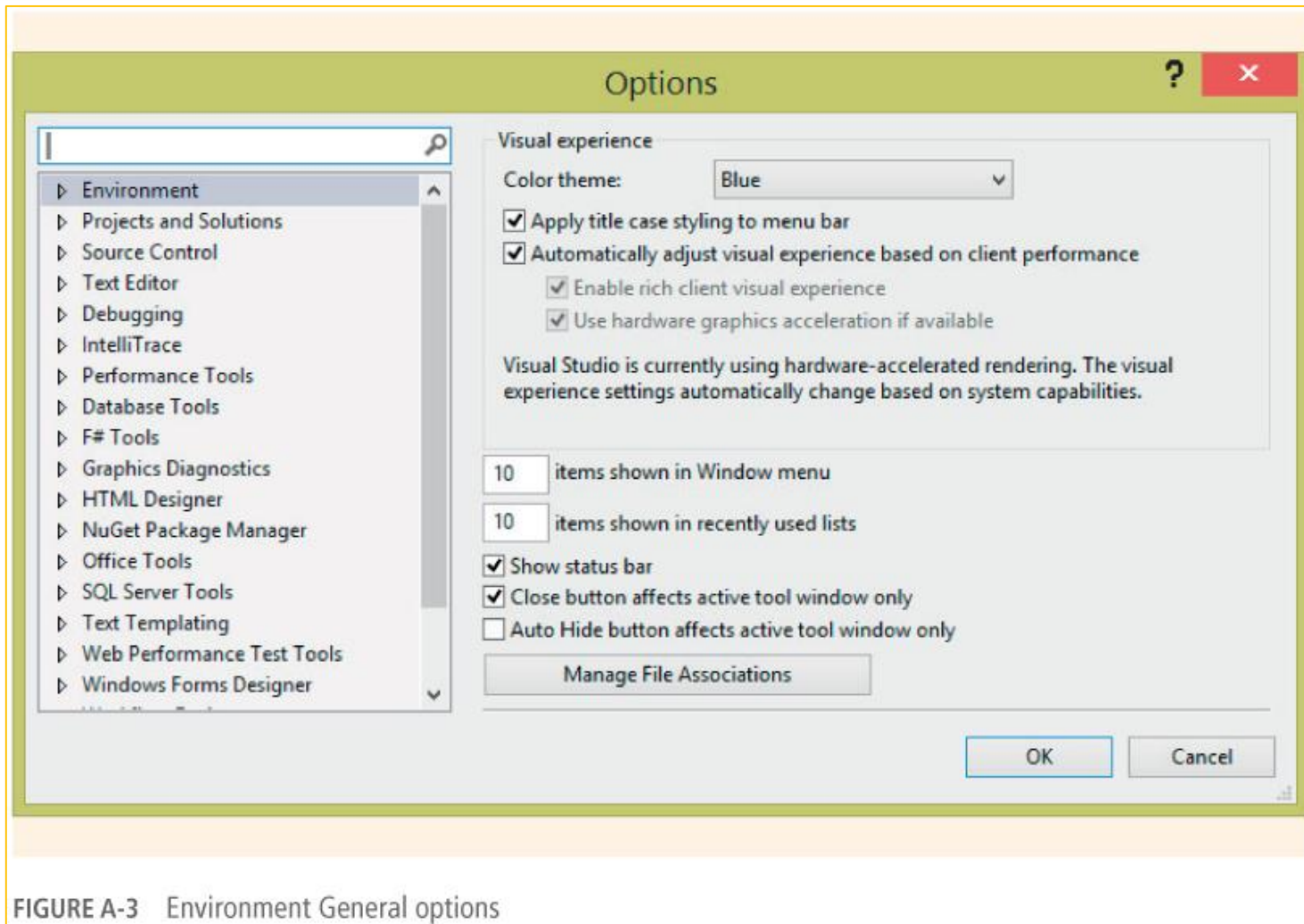
Customizing

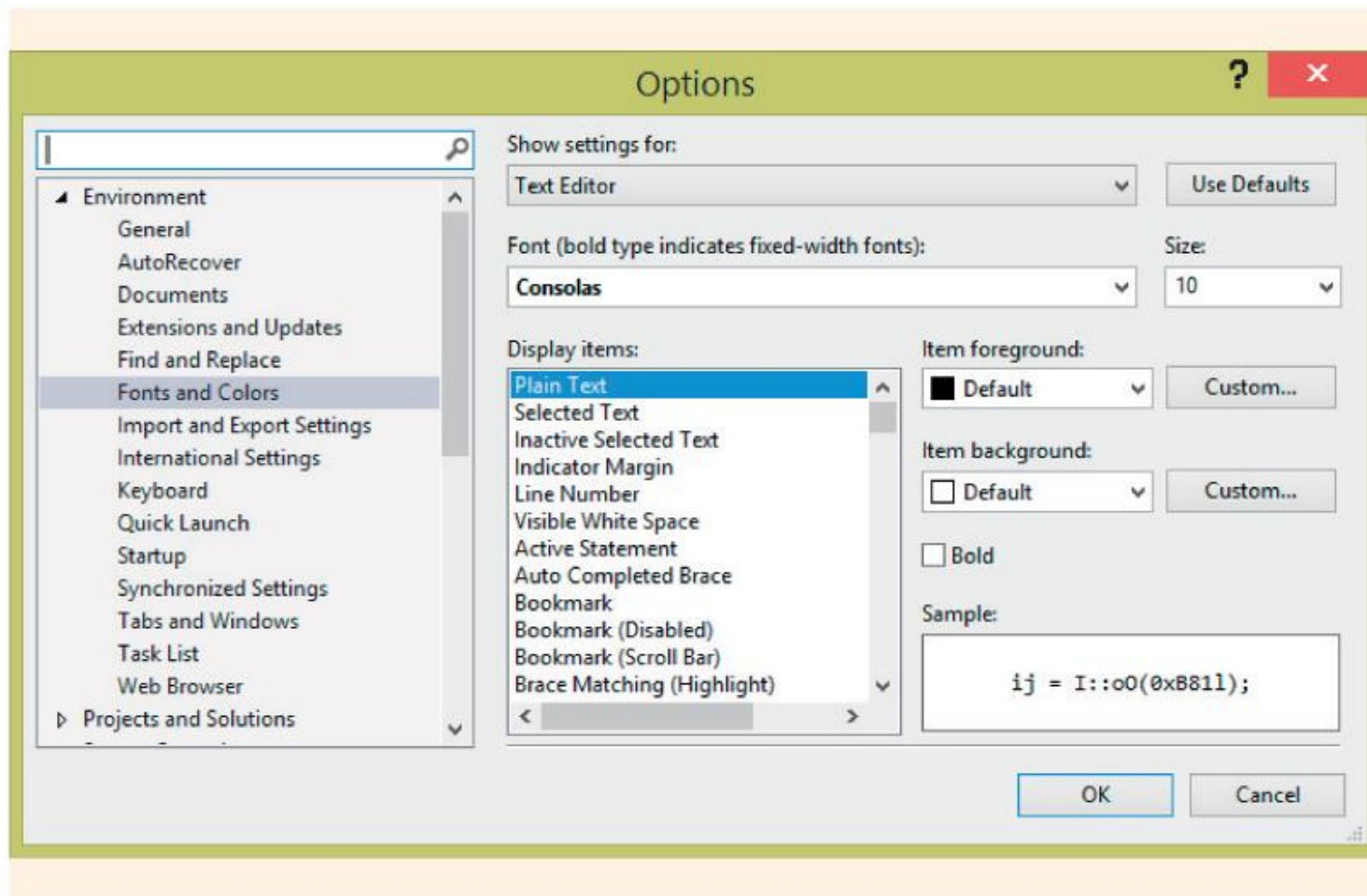FIGURE A-2   Using Tools, Options to configure Visual Studio

Environment

FIGURE A-3   Environment General options

Environment

FIGURE A-4 Setting the fonts and colors

- **Environment**, **Startup** node lets you determine what is opened when you first start Visual Studio

  - **Show Start Page**, **Open Home Page**, **Load last loaded solution**, **Show Open Project** dialog box, **Show New Project** dialog box, or **Show empty environment**

- Set the URL for your Home page and Search page from **Environment**, **Web Browser** node