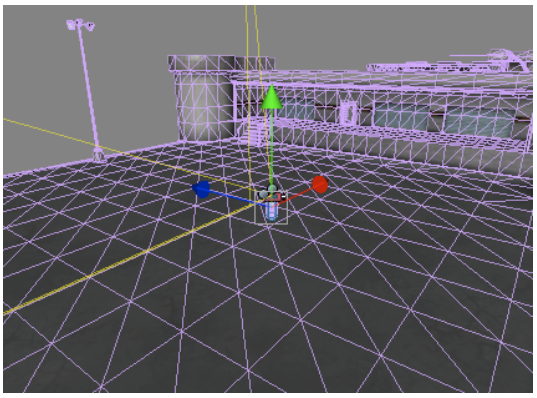
Introduction to Creating a First-Person Shooter (FPS) with Unity



This tutorial will detail how to make a simple **First Person Shooter** (FPS). It will introduce fundamental 3D game programming concepts and give tips on how to think like a games programmer.

Time to complete: 3 - 4 hours.

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Contents

Download the assets for this tutorial from:

www.otee.dk/tutorials/fps_assets.zip

1. Aims of this tutorial

This tutorial assumes a couple of things. Firstly it assumes that you're passionate about computer games, this may be playing, designing or studying them. It also assumes that you have some experience in a computer programming / scripting language. Finally, it assumes that you want to make great games.

This tutorial will teach you how to create a 3D first-person shooter using **Unity**.

2. Prerequisites

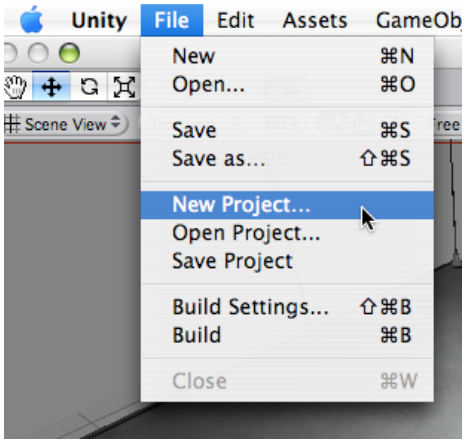
You should already be familiar with the Unity interface and basic scripting concepts. If necessary, complete these tutorials beforehand.

The following development tools are recommended:

- **3D Modeling**: Autodesk Maya 7, Cinema 4D, Cheetah 3D or Blender
- **2D graphics**: Adobe Photoshop

Note: any text that requires the user to take an **action** begins with a '-'.

3. Starting a new project

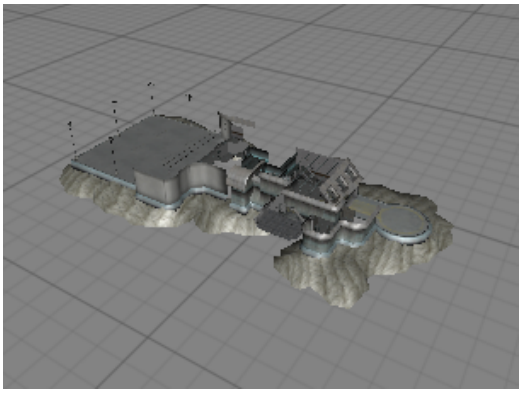


- Start Unity. It's a good idea to keep the icon for Unity in the Dock.
- Create a new project.

In the Project Panel you will see Unity's built in assets; Standard Assets and maybe also Pro Standard Assets if you have the Pro version of Unity. When we create new assets, it's best to put them in folders that group them according to their function, e.g. Rocket, Explosion, Audio etc.

- Download fps_assets.zip and double click on the Unity package. This will import all the scripts and graphics used in the tutorial into the project.

4. Setting up the game environment



Once the assets have been imported, you'll notice there are a lot of folders in the Project panel.

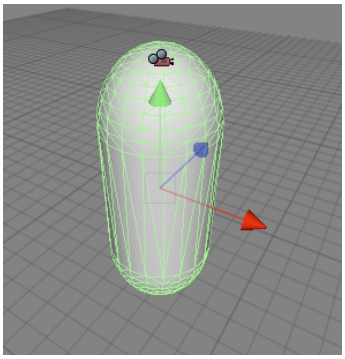
- Drag the mainLevelMesh from Objects/mainLevelMesh/mainLevelMesh.
- With mainLevelMesh still selected in the Project panel, select "Settings" at the top of this panel and in the dialog box that opens, check that "Meshes have colliders" is selected. If we don't do this, the player will simply fall through the level (no collision).

There is no need to add a light to the scene, the level is already fully lightmapped. The imported level uses lightmaps for all lighting which allows us to use pre-baked shadows. Lightmaps are very good for performance, especially if you want to create a complex lighting setup. See the Lightmap HOWTO for more information.

You're now ready to add a character into the environment.

5. Adding the Main Character

We're now going to add in a character for the player to control. Unity has a built in prefab specifically for a first-person controller. This can be found in the Project panel under Standard Assets->Prefabs.



- To add the First Person Controller, click on the arrow beside Standard Assets in the Project panel, a list of assets will appear. Find the folder called Prefabs and click on the arrow on the left hand side. You should now see the First Person Controller asset. Drag this into the Scene view.
- You should see a cylinder object representing the player, 3

large arrows for altering the location in 3D space for the object, and a yellow mesh which shows the object's **viewport** (where it's currently looking). The FPS Controller has a viewport as part of its prefab contains a camera. The FPS Controller is now the default camera, by moving this object, you change the current view in the Game View. You'll also notice that the FPS Controller has a camera icon on top of it. Move the character so that it is above ground level in the environment.

- As we no longer have any need for the Main Camera, you can delete it.
- Press Play, you should now be able to move around the level by using the mouse and keyboard (cursor keys to move or W,S,A,D).

You've now created a very simple FPS, let's give the player a weapon.

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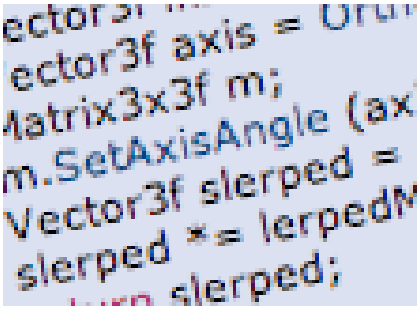
6. Adding a weapon



We're now going to give the player a grenade type object to throw in the environment. To do this, you'll need to create some **Javascript** to tell Unity about the behaviour of the weapon.

So what do we want to do? We want to allow the player to shoot wherever the camera is pointing. However, let's first think about our game character and their weapons. Our game character is seen through the first person view, with the camera positioned at eye level. If the player fires a weapon, the weapon should be launched from wherever their hands are, not from eye level. This means we have to add in a game object to represent the grenade launcher, and place it where the player's hand would be when they hold this weapon. This ensures that the object fires from the correct location.

Create the weapon launcher

Firstly, lets add in a game object to represent the grenade launcher. A **game object** is any item in the 3D world (player, level, sound), **components** are the properties that the game objects has. Therefore you apply components to game objects.

- From the main menu select Game Object->Create Empty, and rename the object to Launcher in the Hierarchy panel. Note, this object is invisible as it is an empty object, however it is just a **placeholder** for our missile launcher.

Now lets get in close to our FPS controller so we can see where to position the weapon launcher.

- Select the FPS controller in the Hierarchy Panel and ensuring that your cursor is over the Scene View, press 'F' (frame selected). This focuses us on the player (the currently selected item).
- Now select the Launcher from the Hierarchy Panel and choose "Game Object->Move to view" from the main menu. Notice how the Launcher object is now placed near the FPS Controller. We can now use the handles to place the launcher approximately where the hands should be. **Note** that you can make the character left or right-handed by altering the location of this object, no need to change any code.

- Make sure your Unity GUI window layout is in 2 split mode (Window->Layouts->2 Split), and press Play in the lower left-hand corner of the GUI. Make sure Launcher is selected in the Hierarchy View and whilst watching the Scene View, move the character around, you'll notice that our Launcher object does not move with our character (you can press Play to stop the game running now).
- To solve this problem drag the Launcher object onto the Main Camera object that belongs to the FPS Controller in the Hierarchy panel. Now run the game again and watch the Scene View, the Launcher should now move with our character. We have associated the Launcher game object with an object that moves in all 3 axis (the camera).

Create the Missile object

Let's create the missile that will be launched when the user clicks the fire button.

- For now we'll use something simple, a sphere. Create a new prefab object by clicking on Assets->Create>Prefab from the Unity menu bar, and rename it to Missile.
- Now create a sphere (GameObject->Create Other->Sphere).
- Now drag the Sphere game object from the Hierarchy Panel onto the Missile prefab in the Project Panel. The icon for the prefab will now change. You can delete the Missile object from the Hierarchy View.

Tip: Any game object which you know you'll need to **instantiate** at run-time should generally be a **prefab**.

Write the Missile Launcher code

The FPS Controller is a prefab consisting of several game objects and components. The FPS Controller itself is a cylinder mesh that only rotates around the y-axis, so if we attach the launcher code (script) to this, then we won't be able to shoot up and down. Therefore, we're going to attach our launcher code to the Main Camera inside the FPS Controller as the camera has the ability to look in any direction.

Let's create our first Javascript code which will describe the behaviour of the Launcher.

- Select Assets->Create->JavaScript, this creates a blank Javascript document.. A new asset appears in the Project Panel entitled NewBehaviourScript. Rename this script to MissileLauncher.

Tip: You can specify which external code **editor** you want Unity to use by clicking on Unity->Preferences then selecting the External Script Editor box.

- Create a new directory inside your Project View called WeaponScripts, we'll put all our weapons scripts in here. Move your MissileLauncher Javascript into here, and also the Missile prefab.

  Let's have a look at the complete Javascript for MissileLauncher:

```
var projectile : Rigidbody;
var speed = 20;
function Update () {
  if (Input.GetButtonDown ("Fire1")) {
    var instantiatedProjectile : Rigidbody = Instantiate (projectile, transform.position,
transform.rotation);

    instantiatedProjectile.velocity = transform.TransformDirection(Vector3 (0,0,speed));

    Physics.IgnoreCollision(instantiatedProjectile.collider, transform.root.collider);
  }
}
```

1 → 2 → 3 → 4 →

Thinking from a high level, what do we want to do? Well, we want to detect when the user has hit the fire button, then (1) instantiate a new missile, and (2) launch it with a certain velocity towards where the user was aiming. Let's examine the code in detail, the numbers below refer to the arrow sections in the above code segment.

1. This detects when the user hits the fire button. Fire1 is mapped to both the left mouse button and the current keyboard configuration (this can be edited from menu Edit->Project Settings->Input).
2. To instantiate an object in Unity we use the **Instantiate** keyword followed by three parameters, (1) the object to instantiate, (2) the 3D position it should be created at, and (3) the rotation the object should have. There is also another constructor, check the API guide, but we'll use this one for now.

   The first part of this code seems reasonable, it is the reference variable to hold the instantiated object. The type of this variable is RigidBody, this is because the missile should have physics behaviour.

   The first parameter, projectile, is the object we want to create. So what is projectile anyway? The Projectile is set by you (i.e. what type of object does the user want to fire), to make things easy we want to assign the projectile in the Unity GUI. To allow this to happen, we declare the variable projectile outside of any function, this makes it public and **exposes** it to the Unity GUI. The projectile object could have been created in code, however if you want to modify (tweak) a variable, it's better to do this from the Unity GUI.

   The second parameter, transform.position, creates the projectile at the same position in 3D space as the launcher. Why the launcher? Well, the script we're creating will be attached to the launcher so if we want to get our current 3D position, transform.position gives that to us (transform talks about the transform the script is attached to).

   The third parameter, transform.rotation, is similar to the second parameter, except it creates the missile with the same rotation properties as the launcher.

3. This part makes our missile move. To do this, we give the missile a velocity, but in which direction (x,y or z)? In the Scene View, click on the FPS Controller, the move arrows appear (press W to make sure), one is red, one is green and one is blue. Red denotes the x-axis, green denotes the y-axis and blue denotes the z-axis. As blue is pointing in the direction that the player is facing, we want to give our missile a velocity in the z-axis.

   Velocity is a property of instantiatedProjectile, how did we know this? Well, instantiatedProjectile is of type RigidBody, and if we look at the API we see that velocity is a property. Take a look at some of the other properties that RigidBody has too. To set the velocity we need to specify the speed in each axis. However, there is one slight issue Objects in 3D are specified using two coordinate models; **local** and **world**. In **local space**, coordinates are relative to the object you are working with. In **world space**, coordinates are absolute, up, for example is always the same direction for all objects. RigidBody.velocity must be specified in world space. So when assigning the velocity, you need to convert from the z-axis in local space (the forward direction), to its respective world space direction. You do this using the transform.**TransformDirection** function which takes a Vector3 type as a parameter. The variable "speed" is also exposed so we can tweak it in the GUI.

4. This turns off collisions between the missile and the player. If we didn't do this the missile would collide with the player when it was instantiated. Look this up in the API under IgnoreCollision.

- Insert the described code into MissileLauncher Javascript, make sure to **save** it.
- Attach the MissileLauncher script to the Launcher in the FPS Controller. You can confirm that the MissileLauncher script is now attached to the Launcher by selecting it in the Hierarchy View and checking that the MissileLauncher script is shown in the Inspector panel.

However, the missile we previously created has not been associated with the projectile variable in our script, this is done in the Unity GUI. The projectile variable is of type RigidBody, so firstly we must ensure that our missile has a RigidBody attached.

- To do this, click on Missile in the Project Panel, then from the main menu bar select Components->Physics->RigidBody. This adds a RigidBody component to the missile we want to fire. We have to do this as the type of object we want to fire must match the type of variable we exposed in the script.
- Now to associate the missile with the projectile variable in the script. Firstly, click on Launcher in the Hierarchy Panel, notice the variable Projectile in the MissileLauncher script section in the Inspector Panel. All we need to do to associate the missile with this variable, is drag the Missile prefab from the Project Panel and drop it onto the Projectile variable.
- Now if you run the game you will be able to shoot a small sphere which will have gravity attached. Try it!

7. Missile explosions

Now we're going to add an explosion when the missile collides with another object. To do this we need to attach behaviour to the missile, i.e., create a new script and add it to the Missile game object.

- Create a new blank script by selecting Assets->Create->Javascript and rename this new script to **Projectile**. Drag the new script to the Weapons folder in the Project Panel.

So what do we want the Projectile script to do? We want to detect when the missile has had a collision, then create an explosion at that point. Let's look at the code:

```
var explosion : GameObject;


function OnCollisionEnter (collision : Collision) {
    var contact : ContactPoint = collision.contacts[0];


    var rotation = Quaternion.FromToRotation(Vector3.up, contact.normal);
    var instantiatedExplosion : GameObject = Instantiate (explosion, contact.point,
            rotation);
    Destroy(gameObject);
}
```

1. Any code that we put inside the **OnCollisionEnter** function is executed whenever the object that the script is attached is in collision with another object.
2. The main task we want to do inside the OnCollisionEnter function is to instantiate a new Explosion at the location in 3D space wherever the missile collided. So where did the collision happen? The function OnCollisionEnter is passed a Collision class which contains this information. The point at which the collision occurred is stored in the ContactPoint variable.
3. Here we use the instantiate function to create an explosion. We know that instantiate takes 3 parameters; (1) the object to instantiate, (2) the 3D position, and (3) the rotation of the object.

   We will assign this to a game object with a particle system later. We'll also want to assign this using the Unity GUI, so we'll expose this variable by making it public (declaring it outside of any function).

   The second parameter, the 3D point at which to instantiate the explosion was determined from the collision class in point 2.

   The third parameter, the rotation to set the explosion to, needs some explanation. We want the rotation of the explosion so that the y-axis of the explosion follows along the surface normal of the surface the missile collided with. This means that for walls the explosion should face outwards, for floors it will face upwards. So what we want to do is to translate the y-axis of the explosion in local space (the y-axis is upwards), to the surface normal (in world space) of the object that was collided with. Essentially the rotation is saying 'make the y-axis of the object point in the same direction as the normal of the surface with which it collided'.

4. Finally, we want to make the missile disappear from the game as it has now collided, we do this by calling the **Destroy()** function with gameObject as a parameter (gameObject denotes the object the script is associated with).

- Add the code into the Projectile Javascript and save it.
- Attach the Projectile Javascript to the Missile.

Now we have to create the explosion that we want to occur whenever the missile collides.

- Firstly, create a new Prefab (call is **Explosion**) that will store the explosion asset. Drag this into the Scene view so you can see how it will be displayed in the final game. Note that the explosion particle system will repeat, only by pressing Play will you see the final rendering (fades etc).
- The standard assets contain a nice explosion prefab with a particle system and a light around the explosion. Drag the explosion prefab under Standard Assets->Particles->Explosion on top of Explosion variable in the Hierarchy View.
- When you've finished with the explosion (and you've happy with how it looks), drag the Explosion from the Hierarchy view onto the Explosion Prefab in the Project view.

Now we can assign the explosion to the missile:

- Ensuring that Missile is selected, fill in the Explosion variable by dragging the Explosion object in in Project view, onto the Missile's Explosion variable in the Inspector Panel.

Defining Explosion Behaviour

Now we have to create one more script which will define the behaviour of the explosion itself.

- Create a new script, call it **Explosion**, and put it in the Weapons folder. Double click on the Explosion script to edit it.

Another common function type for scripts is called **Start()**. Code placed inside here is executed only once when the object it belongs to is instantiated. All we want to do for now is to delete the explosion from the game after a certain amount of time. To do this we use the Destroy() function with a second parameter which specifies how long to wait before deleting.

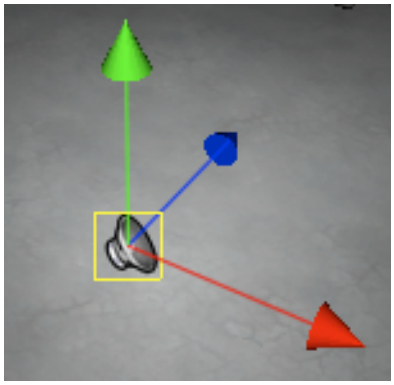
```
var explosionTime = 1.0;

function Start() {
    Destroy (gameObject, explosionTime);
}
```

The explosionTime variable is exposed to the Unity GUI so it can be easily tweaked.

- Insert the above code into the Explosion script, delete the Update() function.
- Attach the Explosion script to the Explosion game object by firstly clicking on the Explosion game object, and then selecting Components->Scripts->Explosion.

Notice how we've tried to group the behaviour as neatly as possibly, code that relates to the explosion is contained within the script that is attached to the Explosion prefab.

- Run the game and wherever your missile collides with the environment, you should see a spark particle system.



8. Sound effects

Our game world has been a little quiet so far, let's add a sound effect to our explosion effect.

Firstly let's assign an audio clip to the Explosion prefab.

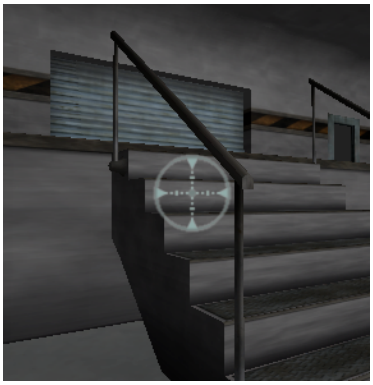
- To allow the Explosion object to be able to accept an audio clip, we add the Audio Source component to it from the main menu (Component->Audio->Audio Source). You'll notice one of the properties of this component is the Audio Clip.

- Assign Sounds->RocketLauncherImpact to the Explosion prefab's "Audio Clip" exposed variable. Unity can play .aiff (and most other uncompressed audio formats).
- Run the game again, our explosion sound effect should be heard when each missile impacts.

9. Adding a GUI

Now let's add a graphical user interface (GUI), more commonly known as a head up display (HUD) to the game. Our simple GUI is only going to contain a crosshair cursor.

Adding a cursor



- Select Textures->aim then choose GameObject->Create Other->GUI Texture.

Note how an aim type cursor appears in the Game view and an aim variable has appeared in the Hierarchy view.

- Play the game. If the missile does not aim at the centre of the cursor, you may want to move the Launcher game object to a higher position.

10. Physics

Now we want objects in our environment to behave as naturally as possible, this is achieved by adding physics. In this section, we're going to add objects to the environment which will move when hit with our missile. Firstly there are some new terms to explain.

Update

Previously, we have entered code inside an Update function, so that we can execute that code every frame, for example to detect if the user has hit the fire button. However, frame rate is not a regular value as it is dependent on the complexity of the scene etc. This irregular timing between frames can lead to unstable physics. Therefore, whenever you want to update objects in your game which involve physics (rigidbodies), code should be

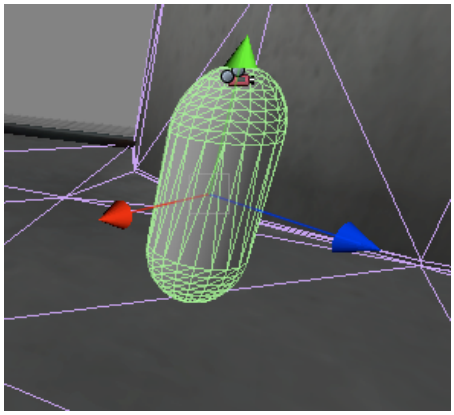
placed inside a **FixedUpdate** function. The **deltaTime** value in Unity is used to determine the time taken between rendering two consecutive frames.

A general distinction between Update and FixedUpdate functions is as follows:

- **Update()** - code inside this function typically updates player behaviour, game logic etc. The value of deltaTime is not consistent when used within this function.
- **FixedUpdate()** - code inside this function typically updates rigidbodies over time (physics behaviour). DeltaTime always returns the same value when called within a FixedUpdate function.

The frequency with which FixedUpdate is called is specified by the Fixed Timestep property in menu option Edit->Project Settings->Time, and can also be altered. This property contains the time in seconds, to get the frames per second value, take the reciprocal of this value.

Tip: When modifying the value for Fixed Timestep (effectively frames per second), be careful to strike a balance; a greater framers per second value will give more stable physics (more accuracy), however the game performance will suffer. Ensure that the game runs quickly and the physics seem realistic.



The final term to explain in this section is **yield**. This can be thought of as a statement to **pause** execution of the current function.

So let's get back to our game, what do we want to do:

1. Allow the user to fire a missile (already done).

2. If the missile collides with another rigidbody, determine if there are any other objects in the vicinity which have rigidbodies attached.

3. For each rigidbody within the force of the explosion, give them a force in the upwards direction, causing them to react to the missile.

Let's look at the code for the **Explosion** Javascript:

```
var explosionTime = 1.0;
var explosionRadius = 5.0;
var explosionPower = 2000.0;

function Start () {
     // Destroy the explosion in x seconds,
     // this will give the particle system and audio enough time to finish playing
     Destroy (gameObject, explosionTime);

     // Find all nearby colliders
1    var colliders : Collider[] = Physics.OverlapSphere (transform.position,
           explosionRadius);

     // Apply a force to all surrounding rigid bodies.
2    for (var hit in colliders) {
          if (hit.rigidbody)
          {
3              hit.rigidbody.AddExplosionForce(explosionPower, transform.position,
                    explosionRadius);
```

```
            }
        }

        // If we have a particle emitter attached, emit particles for .5 seconds
        if (particleEmitter)
        {
            particleEmitter.emit = true;
            yield WaitForSeconds(0.5);
            particleEmitter.emit = false;
        }
}
```

4 

1. This determines if there are any objects with colliders close to where the missile landed. The class function Physics.OverlapSphere() takes two parameters, a 3D position and radius, and returns an **array** of colliders which are contained within the defined sphere.
2. Once the array has been obtained, each of the rigidbodies attached to the colliders can be given a force in a certain direction.
3. This adds a force (explosionPower) in the upwards direction (y-axis), at the location where the missile landed (transform.position). However, as the effect of explosions diminish over distance, the force should not be constant over the entire radius. Rigidbodies closer to the edge of the circumference should have a lesser effect applied than objects at the epicentre of the explosion. This effect is taken into consideration by this function. The exposed variables explosionPower and explosionRadius can be easily tweaked to create a suitable effect.
4. If a particle emitter is attached to our Explosion game object, start it emitting, then wait for 0.5 seconds (yield), then stop it emitting again.

- Update the Explosion Javascript with the new code, save the script.
- Let's create objects to shoot. Create a cube and attach a rigidbody. Duplicate the cube several times and scatter them around.
- Try the game again and shoot objects which have rigidbodies attached. they should now react with an upwards force. Also, try to not shoot the objects directly, but close to them, this will clearly demonstrate how the upwards explosion force is applied over a radius and not only to each object directly.
- Save your scene.

Summary

This tutorial has presented a walkthrough on how to create a first person shooter using Unity. You should now be familiar with the following terms:

- Assets
- Cameras
- Lights
- Viewports
- Prefab
- Colliders

- Rigidbodies
- Javascript
- Game object
- Update / FixedUpdate
- Local / World view

The next tutorial in the series will show you how to build upon these fundamentals by introducing more advanced concepts such as AI and multiple weapons.