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This document is about: **QUANTUM 2**

SWITCH TO

Collider and Body Components

Introduction

The collision and physics behaviour each have their own component in Quantum 2.

- Adding a PhysicsCollider2D/PhysicsCollider3D to an entity, turns entity into a dynamic obstacle or trigger which can be moved via its transform.
- Adding a PhysicsBody2D/PhysicsBody3D allows the entity to be controlled by the physics solver.

Requirements

The Transform2D/Transform3D, PhysicsCollider2D/PhysicsCollider3D and PhysicsBody2D/PhysicsBody3D components are tightly intertwined. As such some of them are requirements for others to function. The complete dependency list can be found below:

Component	Requirement	Transform	PhysicsCollider	PhysicsBody
Transform		✓	✗	✗
PhysicsCollider		✓	✓	✗
PhysicsBody		✓	✓	✓

These dependencies build on one another, thus you have to add the components to an entity in the following order if you wish to enable a PhysicsBody:

1. Transform

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The PhysicsBody Component

Adding the *PhysicsBody* ECS component to an entity enables this entity to be taken into account by the physics engine. *N.B.:* the use of a *PhysicsBody* requires the entity to already have a *Transform* and a *PhysicsCollider* .

You can create and initialize the components either manually in code, or via the EntityPrototype component in Unity.

C#

```
var entity = f.Create();
var transform = new Transform2D();
var collider = PhysicsCollider2D.Create(f, Shape2D.CreateCircle(1
var body = PhysicsBody2D.CreateDynamic(1);

f.Set(entity, transform);
f.Set(entity, collider);
f.Set(entity, body);
```

The same rule applies to the 3D Physics:

C#

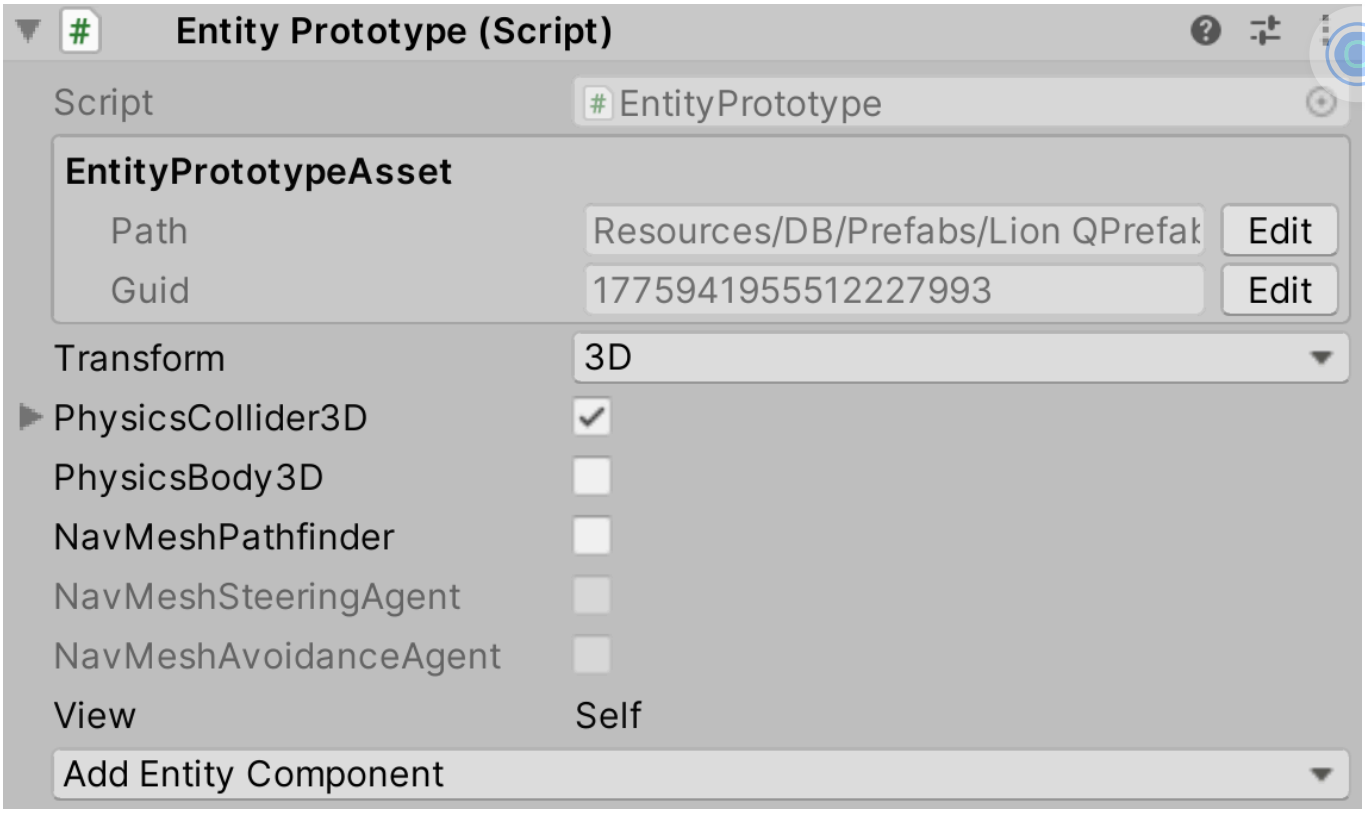
```
var entity = f.Create();
var transform = Transform3D.Create();

var shape = Shape3D.CreateSphere(FP._1);

var collider = PhysicsCollider3D.Create(shape);
var body = PhysicsBody3D.CreateDynamic(FP._1);

f.Set(entity, transform);
```

In case of the EntityPrototype method, the components will be initialized with their saved values.



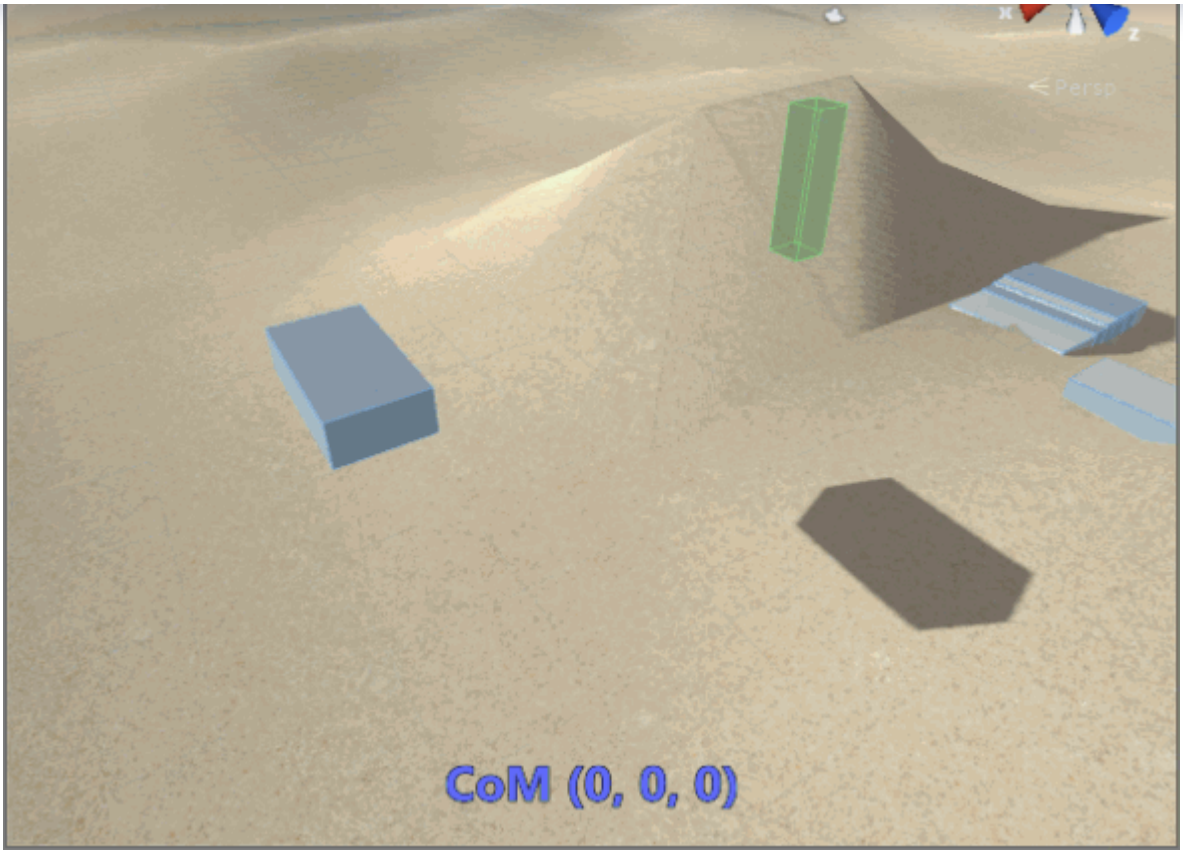
Adjusting an Entity Prototype's Physics Properties via the Unity Editor.

The PhysicsCollider3D supports only supports the following Shape3D for dynamic entities:

- Sphere
- Box

Center of Mass

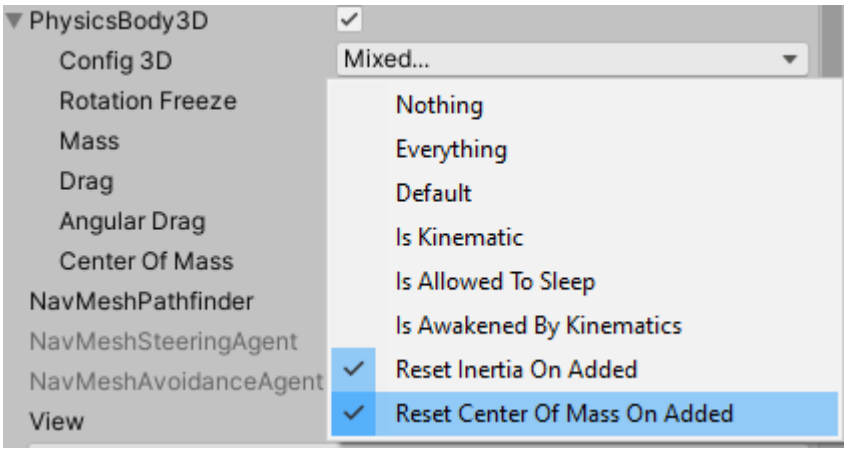
The *Center of Mass*, simply referred to as *CoM* from here on out, can be set on the PhysicsBody component. The CoM represents an offset relative to the position specified in the Transform component. Changing the position of the CoM allows to affect how forces are applied to the PhysicsBody.



Animated examples showcasing how various CoM affect the same PhysicsBody.

By default, the CoM is set to the centroid of the PhysicsCollider's shape. This is enforced by the `Reset Center of Mass On Added` in the PhysicsBody Config drawer.

N.B.: To customize the CoM position, you **HAVE TO** uncheck the `Reset Center of Mass On Added` flag; otherwise the CoM will be reset to the Collider's centroid when the PhysicsBody component gets added to the entity.



Defaults Flags in the PhysicsBody Config viewed in the Unity Editor.

The above configuration is the commonly used for an entity behaving like a uniformly dense body, a.k.a. body with a uniform density. However, the CoM and collider offset are configured separately.

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PhysicsCollider Offset	PhysicsBody CoM	Reset Center of Mass On Added flag	Resulting positions
Default Position = 0, 0, 0 Custom Value = any position differing from the default position			
Default Position	Default Position	On / Off	Collider Centroid and the CoM positions are ***both equal*** to the transform position.
Custom Value	Default Position	On	Collider Centroid is ***offset*** from the transform, and the CoM is ***equal*** to the Collider Centroid position.
Custom Value	Default Position	Off	Collider Centroid is ***offset*** from the transform position. The CoM is ***equal*** to the transform position.
Custom Value	Custom Position	On	Collider Centroid is ***offset*** from the transform position. The CoM is ***equal*** to the Collider Centroid position.
Custom Value	Custom Position	Off	Collider Centroid is ***offset*** from the transform position. The CoM is ***offset*** from the transform position.

Compound Collider CoM

A compound shape's CoM is a combination of all the shape's elements' centroids based on the weighted average of their areas (2D) or volumes (3D).

Key points

In summary, these are the main points you need to takeaway regarding the CoM configuration.

1. The PhysicsCollider offset and PhysicsBody CoM positions are distinct from one another.
2. By default the PhysicsBody Config has the flags `Reset Center of Mass On Added` and `Reset Inertia on Added`.

4. If the `Reset Center of Mass On Added` flag is checked on the PhysicsBody Config, the CoM will be automatically set to the PhysicsCollider centroid upon being added to the entity - regardless of the CoM position specified in the Editor.

Applying External Forces

The PhysicsBody API allows for the manual application of external forces to a body.

C#

```
// This is the 3D API, the 2D one is identical.

public void AddTorque(FPVector3 amount)
public void AddAngularImpulse(FPVector3 amount)

public void AddForce(FPVector3 amount, FPVector3? relativePoint =
public void AddLinearImpulse(FPVector3 amount, FPVector3? relativ
// relativePoint is a vector from the body's center of mass to th
// If a relativePoint is provided, the resulting Torque is comput

public void AddForceAtPosition(FPVector3 force, FPVector3 positio
public void AddImpulseAtPosition(FPVector3 force, FPVector3 posit
// Applies the force/impulse at the position specified while taki
```

As you can gather from the API, angular and linear momentum of the PhysicsBody can be affected by applying:

- forces; or
- impulses.

Although they are similar, there is a key different; **forces** are applying over a period of time, while **impulses** are immediate. You can think of them as:

- Force = Force per deltatime
- Impulse = Force per frame

An **impulse** will produce the same effect, regardless of the simulation rate. However, a **force** depends on the simulation rate - this means applying a force vector of 1 to a body at a simulation rate of 30, if you increase the simulation rate to 60 the deltatime with be half and thus the integrated force will be halved as well.

Generally speaking, it is advisable to use an **impulse** when a punctual and immediate change is meant to take place; while a **force** should be used for something that is either constantly, gradually, or applied over a longer period of time.

Initializing the Components

To initialize a *PhysicsBody* as either a Dynamic or Kinematic body, you can use their respective Create functions. These methods are accessible via the `PhysicsBody2D` and `PhysicsBody3D` classes, e.g.:

- PhysicsBody3D.CreateDynamic
- PhysicsBody3D.CreateKinematic

ShapeConfigs

To initialize PhysicsCollider and PhysicsBody via data-driven design, you can use the *ShapeConfig* types (Shape2DConfig, and Shape3DConfig). These structs can be added as a property to any Quantum data-asset, editable from Unity (for shape, size, etc).

C#

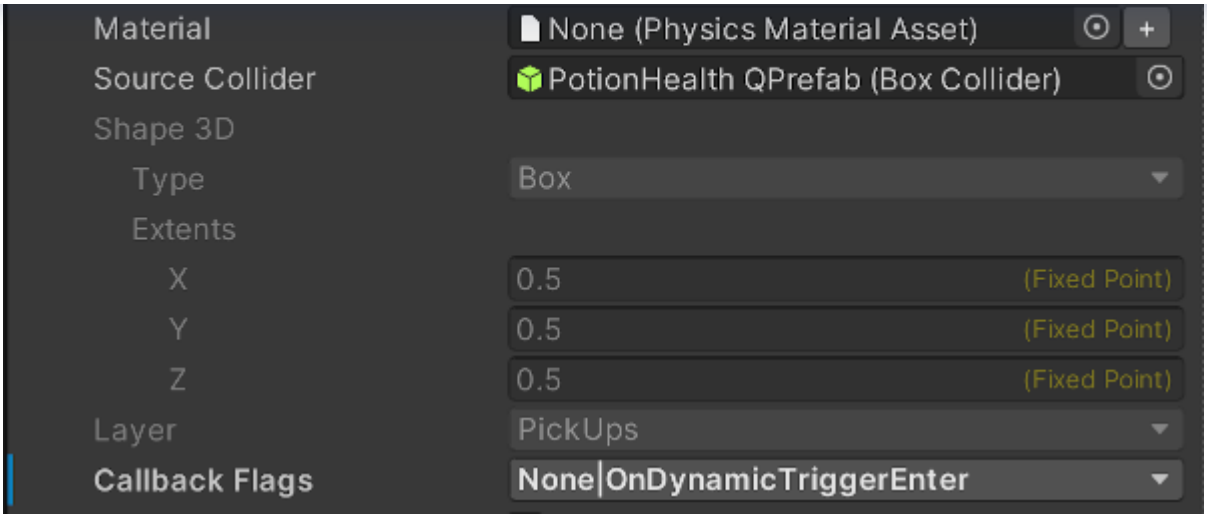
```
// data asset containing a shape config property
partial class CharacterSpec {
  // this will be edited from Unity
  public Shape2DConfig Shape2D;
  public Shape3DConfig Shape3D;
  public FP Mass;
}
```

C#

```
// instantiating a player entity from the Frame object
var playerPrototype = f.FindAsset<EntityPrototype>(PLAYER_PROTOTY
var playerEntity = playerPrototype.Container.CreateEntity(f);

var playerSpec = f.FindAsset<CharacterSpec>("PlayerSpec");

var transform = Transform2D.Create();
var collider = PhysicsCollider2D.Create(playerSpec.Shape2D.Create
var body = PhysicsBody2D.CreateKinematic(playerSpec.Mass);

// or the 3D equivalent:
var transform = Transform3D.Create();
var collider = PhysicsCollider3D.Create(playerSpec.Shape3D.Create
var body = PhysicsBody3D.CreateKinematic(playerSpec.Mass);

// Set the component data
f.Set(playerEntity, transform);
f.Set(playerEntity, collider);
f.Set(playerEntity, body);
```

Enabling Physics Callbacks

An entity can have a set of physics callbacks associated with it. These can be enabled either via code or in the *Entity Prototype*'s *PhysicsCollider* component.



Setting Physics Callbacks via the Entity Prototype's Physics Properties in the Unity Editor.

For information on how to set the physics callbacks in code and **implement** their respective ***signals***, please refer to the *Callbacks* entry in the Physics manual.

Kinematic

In Quantum v2 there are 4 different ways for a physics entity to have kinematic-like behaviour:

1. By having *only* a `PhysicsCollider` **component**. In this case the entity does not have a *PhysicsBody* component; i.e. no mass, drag, force/torque integrations, etc... . You can manipulate the entity transform at will, however, when colliding with dynamic bodies, the collision impulses are solved as if the entity was stationary (zeroed linear and angular velocities).
2. By *disabling* the `PhysicsBody` **component**. If you set the `IsEnabled` property on a *PhysicsBody* to **false**, the physics engine will treat the entity in same fashion as presented in Point 1 - i.e as having only a collider component. No forces or velocities are integrated. This is suitable if you want the body to behave like a stationary entity ***temporarily*** and its config (mass, drag coefficients, etc) for when you re-enable it at a later point.
3. By *setting* the `IsKinematic` property on a `PhysicsBody` **component** to **true**. In this case the physics engine will not move affect the *PhysicsBody* itself, but the body's linear and angular velocities will still have affect **other bodies** when resolving collisions. Use this if you want to control the entity movement instead of letting the physics engine do it, and know that you have the responsibility to move an entity and control a body's velocity manually, while still having other dynamic bodies react to it.
4. By *initializing* the `PhysicsBody` with `CreateKinematic` . If the body is expected to behave as kinematic during its entire lifetime, you can simply create it as a kinematic body. This will have the *PhysicsBody* behave like in 3 from the very beginning. If the body needs to eventually become dynamic one, you simply create a new one with the `CreateDynamic` method and set

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The PhysicsCollider Component

Disabling / Enabling the Component

Since Quantum 2.1, the `PhysicsCollider` component is equipped with an `Enabled` property. When setting this property to `false`, the entity with the `PhysicsCollider` will be ignored in the `PhysicsSystem`.

As the `PhysicsBody` requires an *active* `PhysicsCollider`, it will be effectively disabled as well.

Changing the Shape at Runtime

It is possible to change the shape of a **PhysicsCollider** after it has been initialized.

C#

```
var collider = f.Get<PhysicsCollider3D>(entity);
collider.Shape = myNewShape;
f.Set(entity, collider);
```

When a **PhysicsBody** is first added, it calculates the inertia and CoM based on the shape of the PhysicsCollider. As such it is recommended to call `ResetInertia` and `ResetCenterOfMass` after changing the collider's shape.

C#

```
// following the snippet above

var body = f.Get<PhysicsBody3D>(entity);
body.ResetCenterOfMass(f, entity); // Needs to be called first
```

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> The call order is important here! `ResetCenterOfMass()` **HAS TO BE** called first, and then `ResetInertia()`.

`ResetCenterOfMass` in particular needs to be called if any of the following is true for the old and/or new shape:

- the shape has a position offset
- the shape is a compound shape
- the center of mass has an offset

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