VVnA R Package

Aous Abdo

Tuesday, August 12, 2014

Contents

1 Introduction

The VVnA "Validation, Verification, and Accreditation" package is a package intended for ....

2 Functions

2.1 Projectile Motion

Projectile motion in vacuum and in air are calculated with the `projectile` and `projFrictionLin` functions respectively. when considering air friction effects on projectiles, we only consider the viscous drag which is related to the velocity `v`. The Inertial drag realted to the square of the velocity is not treated in this package.

In each of these two cases, a function will return the following projectile parameters:

1. `x`: Displacement in the horizontal direction as a function of time (in meters)
2. `vx`: Speed in the horizontal direction as a function of time (in m/s units)
3. `y`: Displacement in the vertical direction as a function of time (in meters)
4. `vy`: Speed in the vertical direction as a function of time (in m/s units)
5. `y_x`: Displacement in the vertical direction as a function of horizontal displacement (in meters)

In all cases, it is assumed that there are no motion in the lateral direction.

2.1.1 Projectile Motion in Vaccum

Arguments of the `projectile` function are:

1. `v0`: Initial velocity in m/s
2. `y0`: Initial height in m
3. `theta0`: Initial angle in degrees
4. `t`: Time of flight in seconds

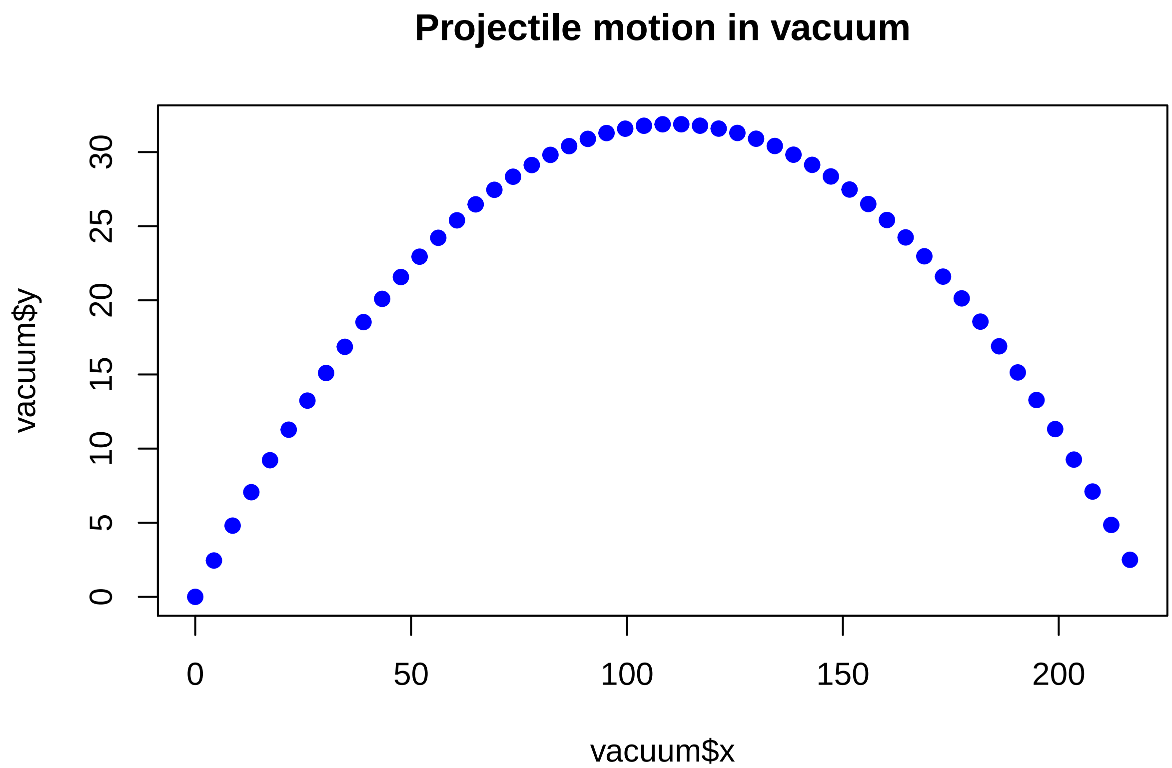
For vectors of length `1` for all arguments, the function will return a list of projectile parameters for those arguments. For example for an initial velocity `v` of `30 m/s`, initial height `y` of `0 m`, initial projectile angle `theta0` of `30 degrees`, and at time `t=3 seconds` we get:

```
projectile(t = 3, y0 = 0, v0 = 30, theta0 = 30)
```

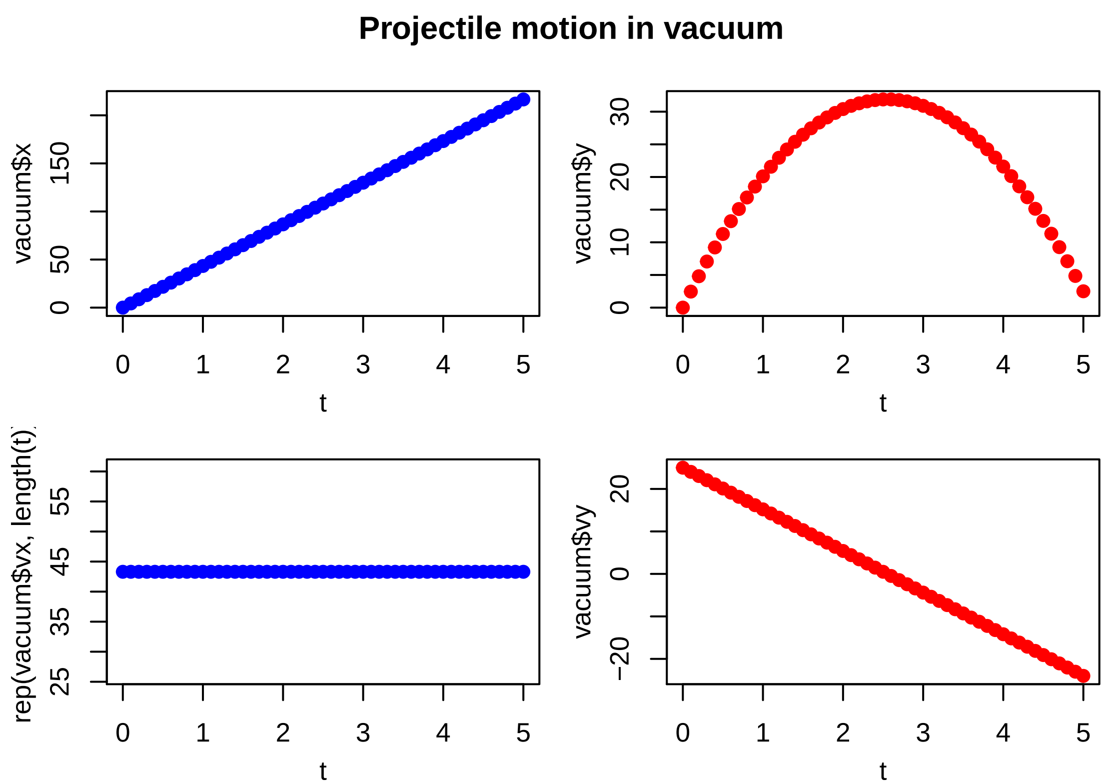
```
## $x
## [1] 77.94229
##
## $vx
## [1] 25.98076
##
## $y
## [1] 0.9
##
## $vy
## [1] -14.4
##
## $y_x
## [1] 0.9
```

One can also pass a vector of length `> 1` for any individual input parameter. This is most useful for the time parameter `t`:

```
vacuum <- projectile(t = seq(0, 5, 0.1), y0 = 0, v0 = 50, theta0 = 30)
plot(vacuum$x, vacuum$y, pch = 19, col = "blue", main = "Projectile motion in vacuum")
```




```
t <- seq(0, 5, 0.1)
vacuum <- projectile(t = t, y0 = 0, v0 = 50, theta0 = 30)
## prepare
## grid
par(mfcol = c(2, 2), mar = c(3.5, 3, 1, 1), oma = c(2, 2, 2,
    2), mgp = c(2.2, 1, 0))
## plot
## outputs
plot(t, vacuum$x, pch = 19, col = "blue")
plot(t, rep(vacuum$vx, length(t)), pch = 19, col = "blue")
plot(t, vacuum$y, pch = 19, col = "red")
plot(t, vacuum$vy, pch = 19, col = "red")
title("Projectile motion in vacuum", outer = TRUE)
```



2.1.2 Projectile Motion in Air

Arguments of the `projFrictionLin` function are:

1. `v0`: Initial velocity in m/s
2. `y0`: Initial height in m
3. `theta0`: Initial angle in degrees
4. `t`: Time of flight in seconds
5. `b`: drag coefficient in Newtons.seconds/meters
6. `m` mass of object in kg

For vectors of length `1` for all arguments, the function will return a list of projectile parameters for those arguments. For example for an initial velocity `v` of `30 m/s`, initial height `y` of `0 m`, initial projectile angle `theta0` of `30 degrees`, drag coeffiecient `b` of 0.5, mass of projectile `m` of 5 kg, and at time `t=3 seconds` we get:

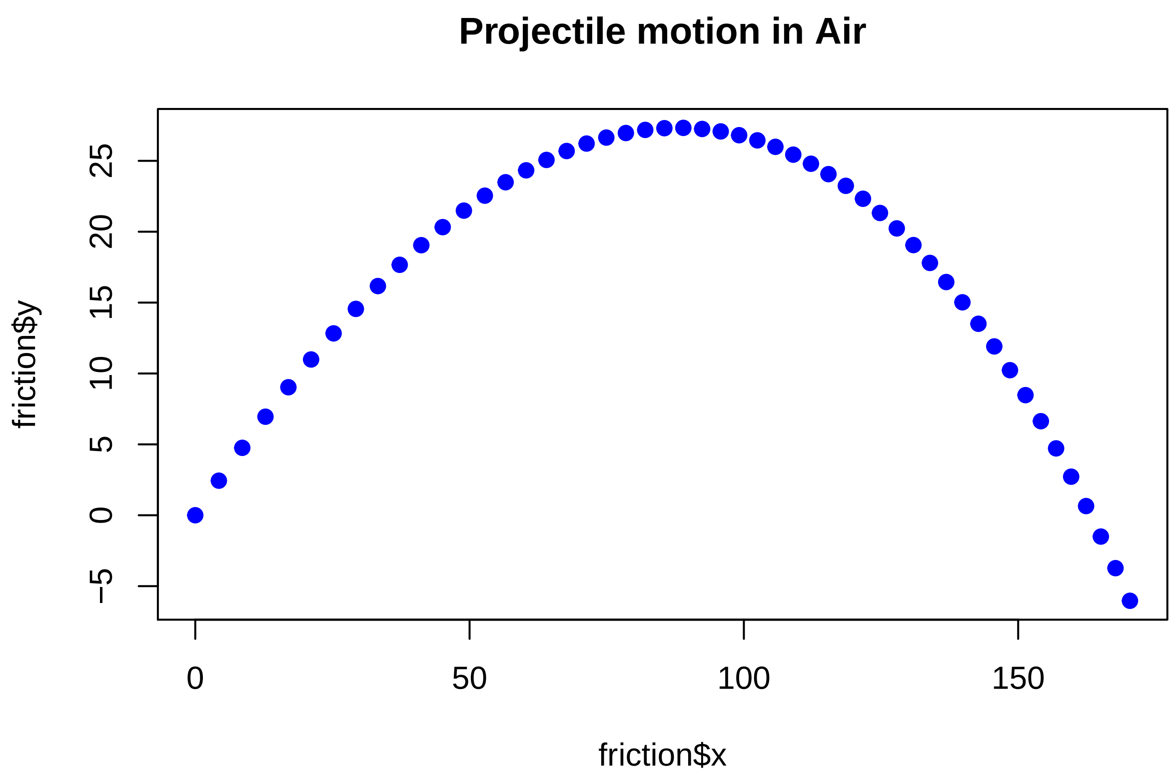
```
projFrictoinLin(t = 3, y0 = 0, v0 = 30, theta0 = 30, b = 0.5,
    m = 5)
```

```
## $x
## [1] 67.3374
##
## $vx
## [1] 19.24702
```

```
##
## $y
## [1] -1.124589
##
## $vy
## [1] -14.28754
##
## $y_x
## [1] -1.124589
```

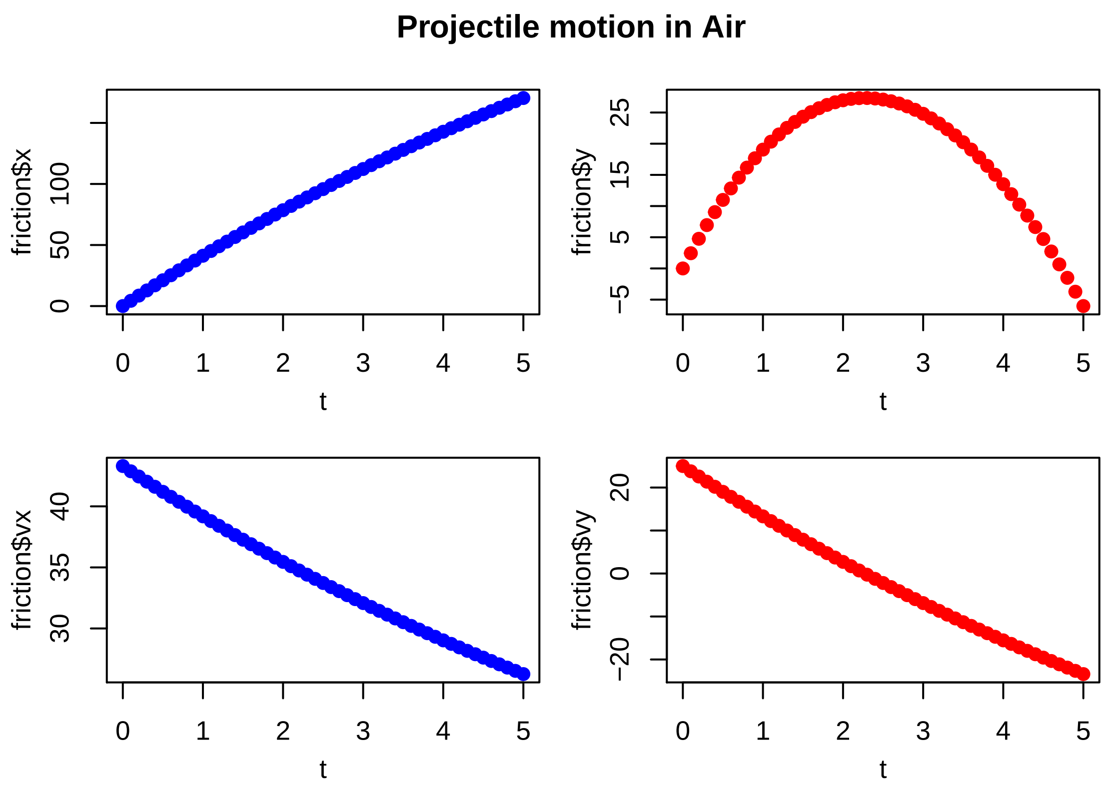
One can also pass a vector of length `> 1` for any individual input parameter. This is most useful for the time parameter `t`:

```r
friction <- projFrictoinLin(t = seq(0, 5, 0.1), y0 = 0, v0 = 50,
    theta0 = 30, b = 0.5, m = 5)
plot(friction$x, friction$y, pch = 19, col = "blue", main = "Projectile motion in Air")
```




```r
t <- seq(0, 5, 0.1)
friction <- projFrictoinLin(t = t, y0 = 0, v0 = 50, theta0 = 30,
    b = 0.5, m = 5)
## prepare
## grid
par(mfcol = c(2, 2), mar = c(3.5, 3, 1, 1), oma = c(2, 2, 2,
    2), mgp = c(2.2, 1, 0))
## plot
```

```r
## outputs
plot(t, friction$x, pch = 19, col = "blue")
plot(t, friction$vx, pch = 19, col = "blue")
plot(t, friction$y, pch = 19, col = "red")
plot(t, friction$vy, pch = 19, col = "red")
title("Projectile motion in Air", outer = TRUE)
```



2.1.3 Comparing Projectile Motion

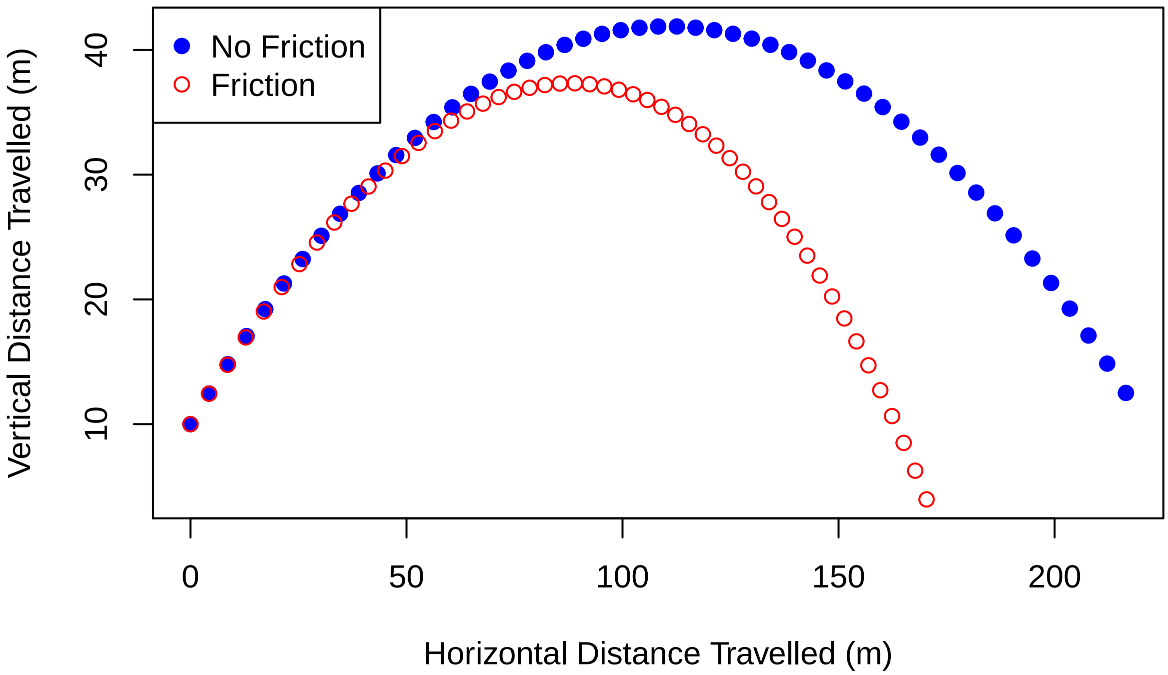
In the example below we compare projectile motion in vacuum to that in air:

```r
par(mfcol = c(1, 1))
vacuum <- projectile(t = seq(0, 5, 0.1), y0 = 10, v0 = 50, theta0 = 30)
friction <- projFrictoinLin(t = seq(0, 5, 0.1), y0 = 10, v0 = 50,
    theta0 = 30, b = 0.5, m = 5)

x <- vacuum$x
y <- vacuum$y
xf <- friction$x
yf <- friction$y_x

plot(x, y, col = "blue", pch = 19, ylim = c(min(y, yf), max(y,
    yf)), xlab = "Horizontal Distance Travelled (m)", ylab = "Vertical Distance Travelled (m)")
points(xf, yf, col = "red", pch = 21)
```

```r
legend(x = "topleft", legend = c("No Friction", "Friction"),
    col = c("blue", "red"), pch = c(19, 21))
```



2.2 The jit Function

The `jit` function is used to randmoize a given vector. It has two modes, `norm` and `uniform`:

`norm`: randomizes a numerical vector by drawing samples from a noraml distribution. `uniform`: randomizes a numerical vector by drawing samples from a uniform distribution.

In the example below we randomize the number `40`, `5` times by drawing from a normal distribution with mean equal to the value to be ranomized, `40`, and a standard deviation equal to 3, passed to the `mean` argument:

```r
jit(x = 40, n = 5, method = "norm", amount = 3)
```

```
## [1] 36.71655 37.18797 44.91630 41.24357 41.24109
```

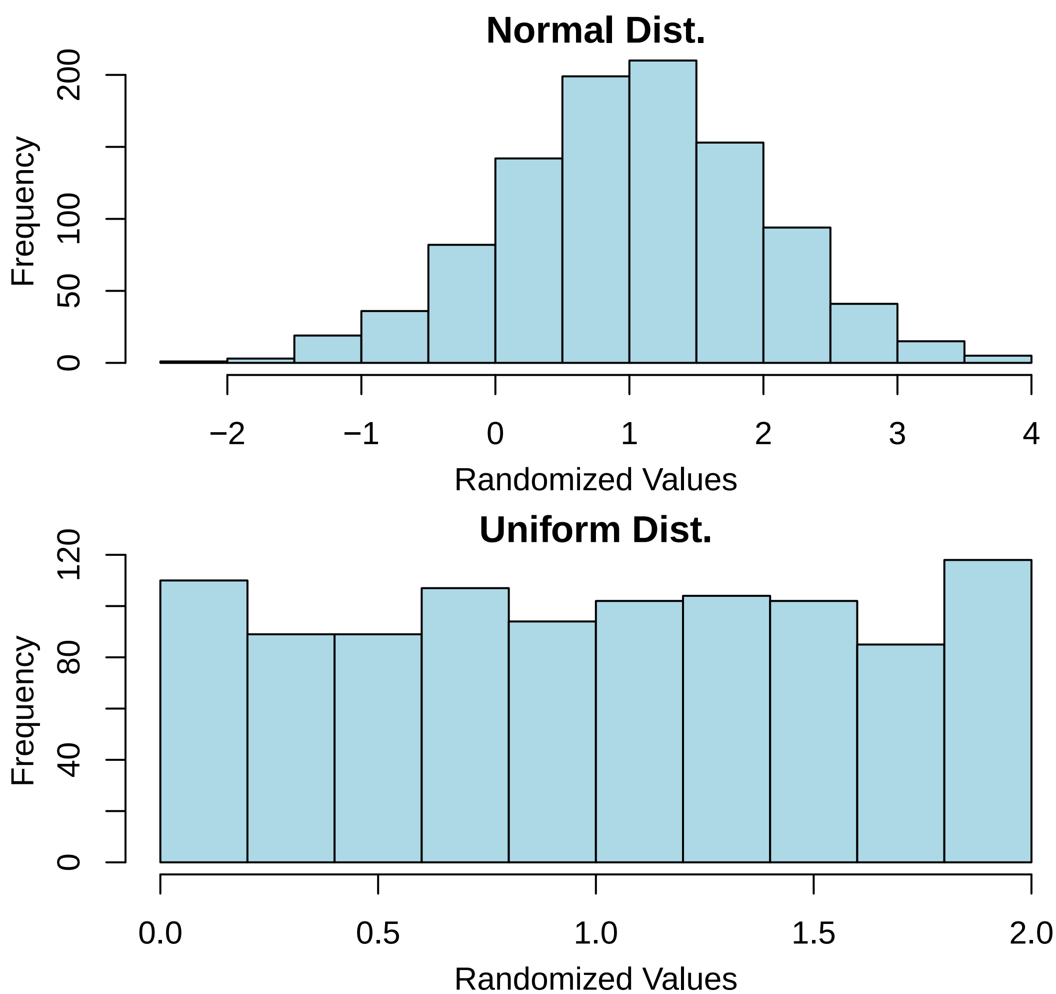
The example below does a similar ranomization, jittering, but with a uniform distribution:

```r
jit(x = 40, n = 5, method = "uniform")
```

```
## [1] 39.96323 40.14607 39.68523 40.28043 39.26943
```

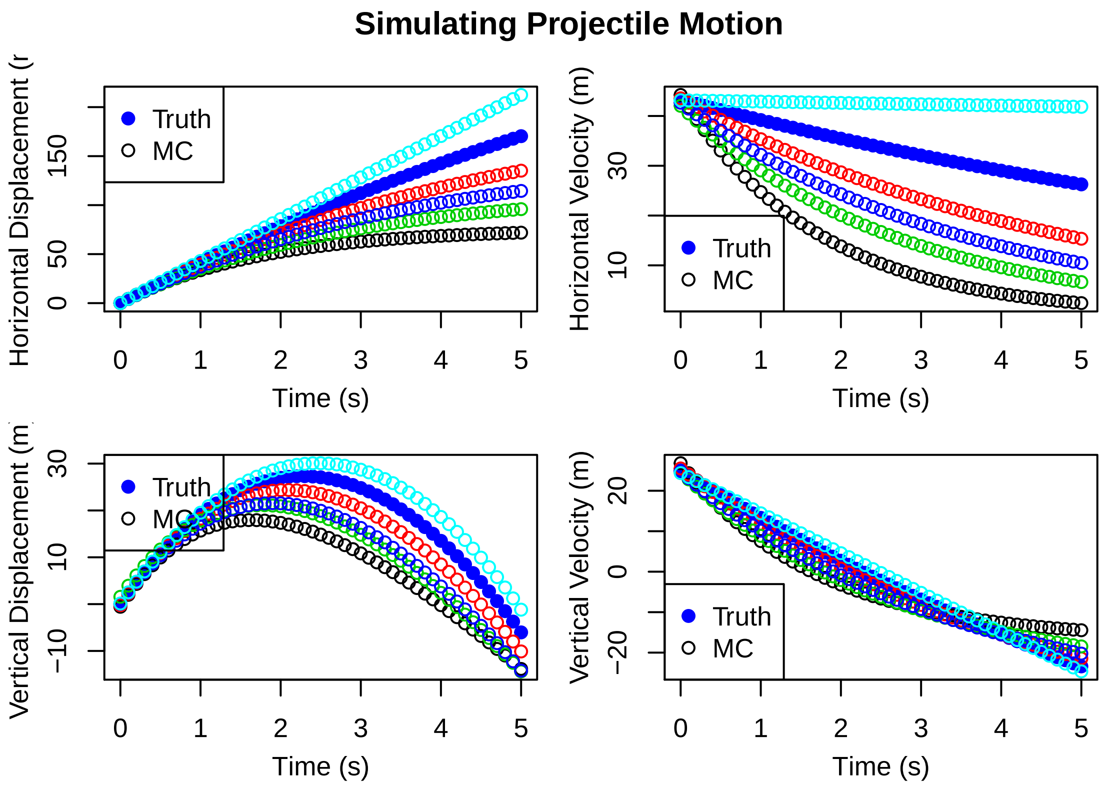
Please notice that the `jit` function with the `uniform` method is essentially equivalent to the `jitter` function in R.

```
par(mfrow = c(2, 1), mar = c(3.5, 3, 1, 1), oma = c(2, 2, 2,
    2), mgp = c(2.2, 1, 0))
hist(jit(x = 1, n = 1000, method = "norm", amount = 1), main = "Normal Dist.",
    xlab = "Randomized Values", col = "lightblue")
hist(jit(x = 1, n = 1000, method = "uniform", amount = 1), main = "Uniform Dist.",
    xlab = "Randomized Values", col = "lightblue")
```



3 Simulations

A detailed example of generating simulations can be found in `example_2.r` in the `example` directory. An output of this exmaple is shown below:


Simulating Projectile Motion
Truth
MC
Horizontal Displacement (r
Horizontal Velocity (m)
Vertical Displacement (m
Vertical Velocity (m)
Time (s)
0
50
150
10
30
−10
20
−20
1
2
3
4
5