Stone Throw Graph

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This is a python programme that can describe the motion of a ball thrown using the kinematic equation. The programme can then display the motion of the ball, which is thrown vertically upwards at the edge of a 50 m high cliff with an initial velocity of 40 ms^{-1}, on a graph of height of the ball as a function of time, over a 10-second period. Using this graph, we can then estimate the time taken for this ball to hit the ground at the base of the cliff.

The motion of the ball can be described with the following kinematic equation:

$$x(t) = x_0 + v_0t + \frac{1}{2}at^2$$

Where x_0 is the initial position, v_0t is the initial velocity, a is acceleration and t is time.

It is important to remember we must consider the effects of gravity on the upward and downward speed of the the ball, where,

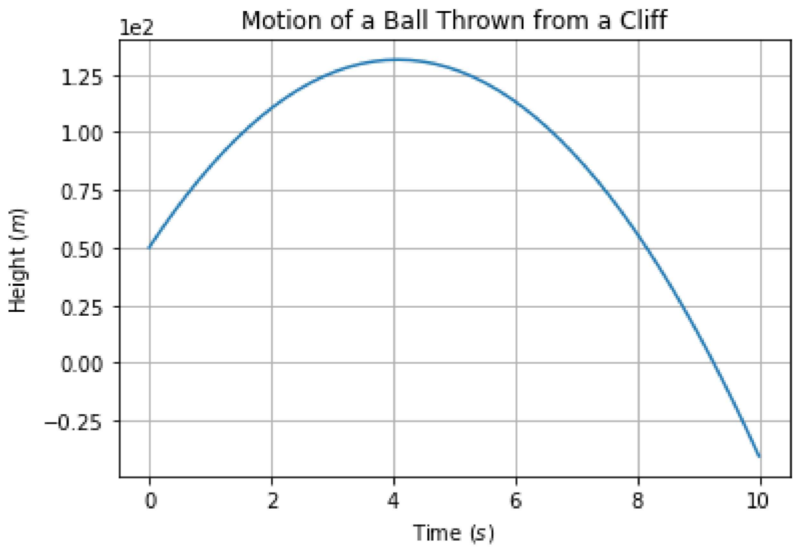
$$g = (-/+)\, 9.81ms^2$$

- Input given values for intial position, initial velocity and acceleration/deceleration
- Calculate the motion of the ball as a function of time using the kinematic equationin an array operation
- Output a graph of the height of the ball as a function of time
- Output a graph of the height of the ball as a function of time zoomed in on the region where the height value is 0
- Estimate the time taken for the ball to reach the ground

In [13]:

```
# Numpy is needed for our calculations
import numpy as np

# Matplotlib is needed to plat a graph of Height vs Time
import matplotlib.pyplot as plt
%matplotlib inline

# Terms used in equation:
x_0 = 50 # Initial position of ball in m
```

```python
v_0 = 40 # Initial velocity of ball in ms^-1
a = -9.81 # Acceleration of ball, due to gravity, in ms^-2

# Define a linearly spaced array of time values, t in seconds
t = np.linspace(0, 10)

# in an array operation calculate the height of the ball, h as a function of time, t
h = x_0 + v_0*t + 0.5*a*t**2

# plot the graph of the height of the ball as a function of time
plt.plot(t, h)
plt.title("Motion of a Ball Thrown from a Cliff")
plt.xlabel("Time $(s)$")
plt.ylabel("Height $(m)$")
plt.ticklabel_format(style = 'sci', axis = 'both', scilimits = ( -2,2) )
plt.grid()
plt.show()
```



In order to find the most accurate estimate of how long it takes the ball to hit the ground possible from our graph, we must zoom-in on the region of interest.
In this case, this means producing a zoomed-in graph to estimate the y-value, time, where the x-value, height, is 0.

In [14]:
```python
# Zoom-in on the graph to find the probable time taken for the ball to hit the ground
plt.plot(t, h)
plt.xlim(8, 10)
plt.ylim(-2.5, 2.5)
```

```python
plt.title("Motion of a Ball Thrown from a Cliff")
plt.xlabel("Time $(s)$")
plt.ylabel("Height $(m)$")
plt.ticklabel_format(style = 'sci', axis = 'both', scilimits = ( -2,2) )
plt.grid()
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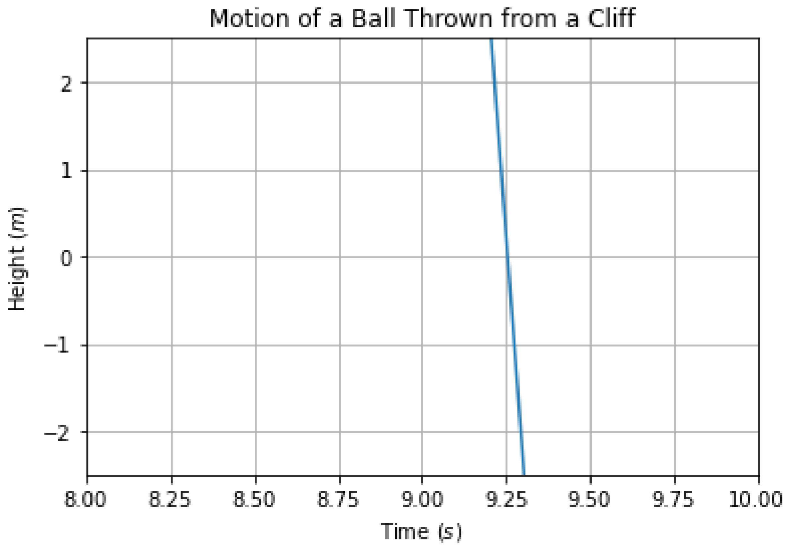

From the graph in the code cell above, we can estimate that the point on the graph whre h = 0 is (0, 9.25). This means that the time taken for the ball to hit the ground is approximately 9.25 seconds.