COMP 768 Homework 1

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1.1 Projectile

1.1.1 Performance

This section presents the analysis of the projectile using RK-4 and Euler integration. Table 1.1 lists the average update time for both methods in milliseconds. As expected, RK-4 was slower than Euler owing to the fact that it requires 4 derivatives as opposed to just the one required by Eular.

Table 1.1: **Average update time**

Scenario	**Eular(ms)**	(ms)RK4
Projectile	0.0176	0.01992
Spring	10	10

In both scenarios, RK-4 takes longer. Note- parameters for projectile m=5; p = 2; b = 1; t=0.001s ; parameters for projectile m=5; p = 2; b = 1; t=0.001s.

1.1.2 Stability

Figure 1.1 illustrates the trajectory of a particle using the methods at different step sizes. It can be seen from the figure that there is very little variation between the RK4 trajectories at t=.1, t=.01 and t=.001 whereas their is a noticeable difference between Euler at t=.1 and t=.001. Hence, RK4 is stable as compared to Euler.

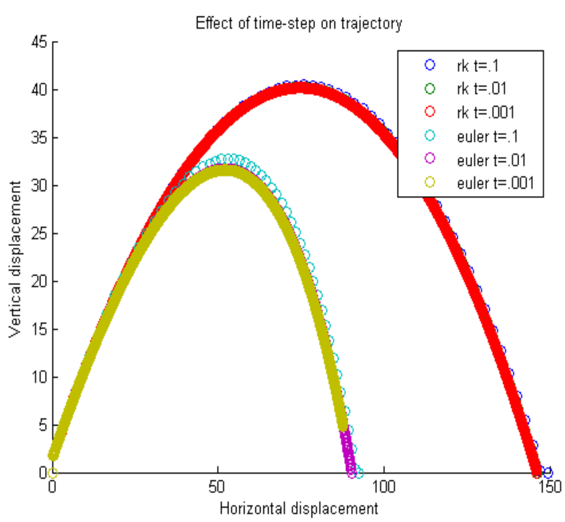

Figure 1.1: RK4 and Euler with varying stepsize.

1.1.3 Effect of Powder

Figure 1.2 illustrates the trajectory of a particle using RK4 and different values of the explosive powder. Since the instantaneous acceleration as a result of the explosive power is directly proportional to the amount of powder, the behavior is as expected: increasing the powder increases the maximum vertical height and horizontal range achieved by the projectile.

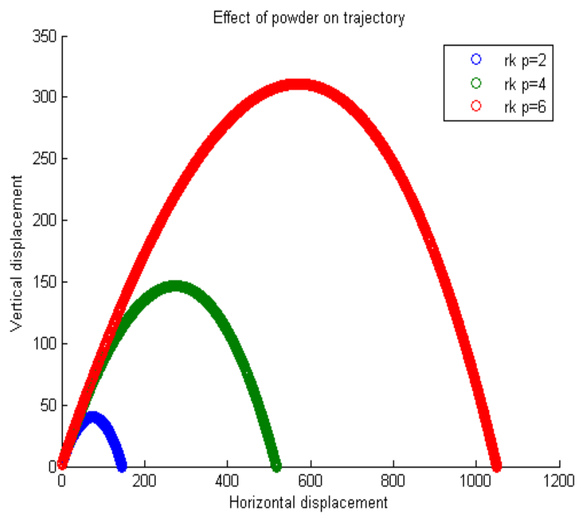

Figure 1.2: Effect of powder on trajectory using RK4.

1.1.4 Effect of Mass

Figure 1.3 illustrates the trajectory of a particle using RK4 and different values of mass. Since the instantaneous acceleration as a result of the explosive power is inversely proportional to the mass, the behavior is as expected: increasing the mass reduces the maximum vertical height and horizontal range achieved by the projectile.

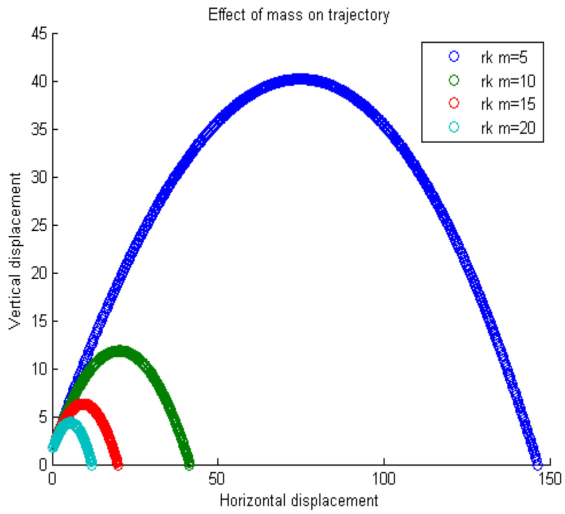

Figure 1.3: Effect of mass on trajectory using RK4.

1.1.5 Effect of Drag

Figure 1.4 illustrates the trajectory of a particle using RK4 and different values of the drag cofficient. In my implementation, I have assumed a linear air drag i.e. $F_{drag} = -b.v$. The behavior is as expected: increasing the drag coefficient reduces the maximum vertical height and horizontal range achieved by the projectile.

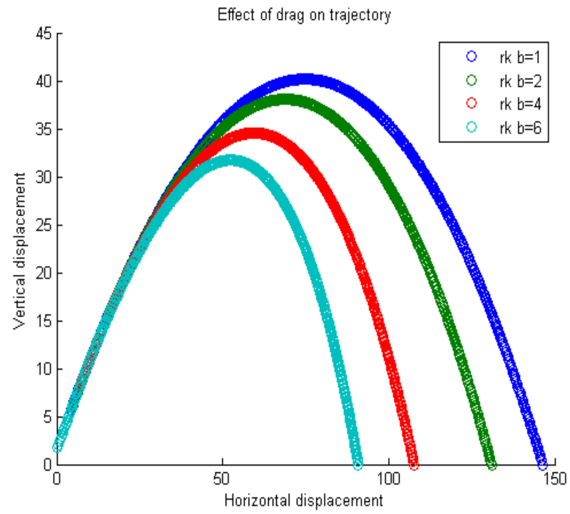

Figure 1.4: Effect of drag on trajectory using RK4.

1.2 Spring-Mass

1.2.1 Stability

Figure 1.5 illustrates the oscillations of a particle using the methods at different step sizes. It can be seen from the figure that there is very little variation between the RK4 trajectories at t=.01, t=.05 whereas Euler diverges considerable at t=.05 as compared to t=.01. Hence, RK4 is stable as compared to Euler.

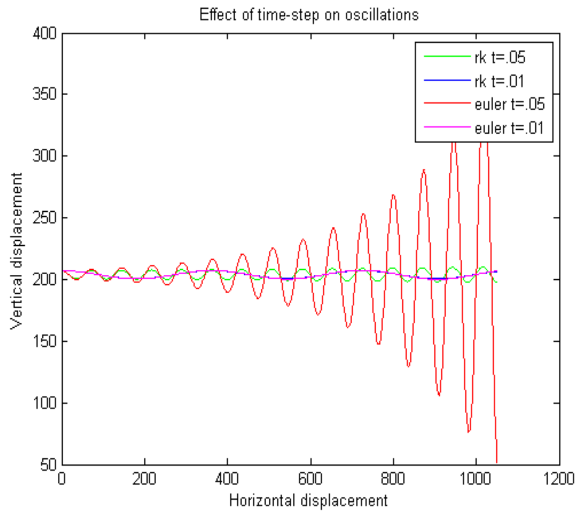

Figure 1.5: RK4 and Euler with varying stepsize.

1.2.2 Effect of Spring Constant

Figure 1.6 illustrates the oscillations of a particle using RK4 and different values of the spring constant. It can be seen that the time period decreases with increasing spring constant which is as expected since the Time Period is inversely proportional to the spring constant.

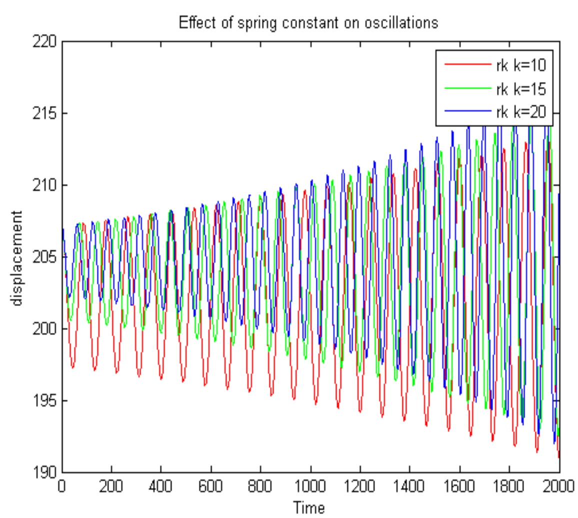

Figure 1.6: Effect of spring constant on oscialltions using RK4.

1.2.3 Effect of Mass

Figure 1.7 illustrates the oscillations of a particle using RK4 and different values of mass. Since, the Time Period is directly proportional to the mass, we see an increase in the Time Period of the oscillations as the mass increases.

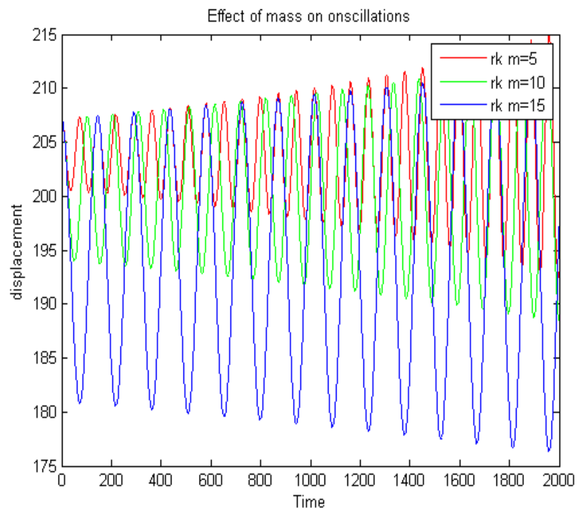

Figure 1.7: Effect of mass on oscillations using RK4.

1.2.4 Specific Use Cases

Figure 1.8 illustrates the trajectory of a particle using RK4 for two cases - a) mass = 5 kg, k = 15 b) mass = 10 kg, k = 20 . As mass increases, we expect the Time Period to increase proportionally. On the other hand, as k increases, we expect the time period to decrease proportionally. However, since in case(b), the mass doubled while the spring constant only increased 1.3 times, the effect of mass outweighed the effect of the spring constant. Hence, the Time Period actually increased in case(a).

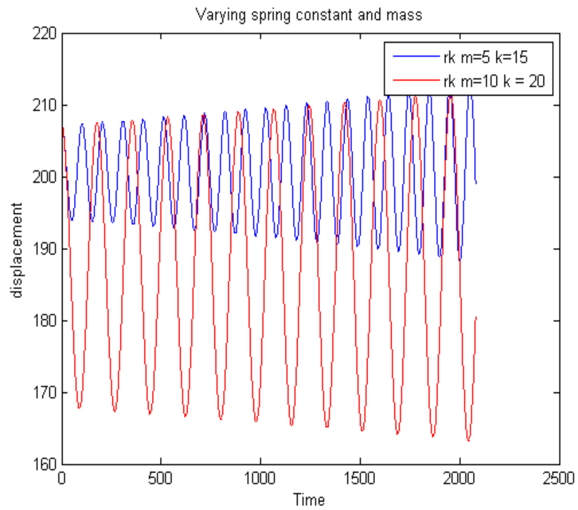

Figure 1.8: Comparing two use cases.

1.3 Conclusion

As expected, RK4 was more stable than Euler. Furthermore, the timing analysis showed that it was fractionally more expensive than Eular on an average.