Simulation Engineering Exercises 05

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Program: ITIS
Language: JAVA
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1. Circus Trapeze with Monte Carlo

Repeated random samples of model input variables over many simulation runs defines a Monte Carlo Simulation.

Assumptions:

Track the changes Trapeze motion (period) with different artist start position, start velocity and swing position.
Length changes between 9.5m and 10.5m randomly (uniform).
Initial velocity changes 0.25 to 0.35 rad/sec randomly (uniform).
Initial theta changes between 55 to 65 degrees randomly (uniform).

Mathematical Model:

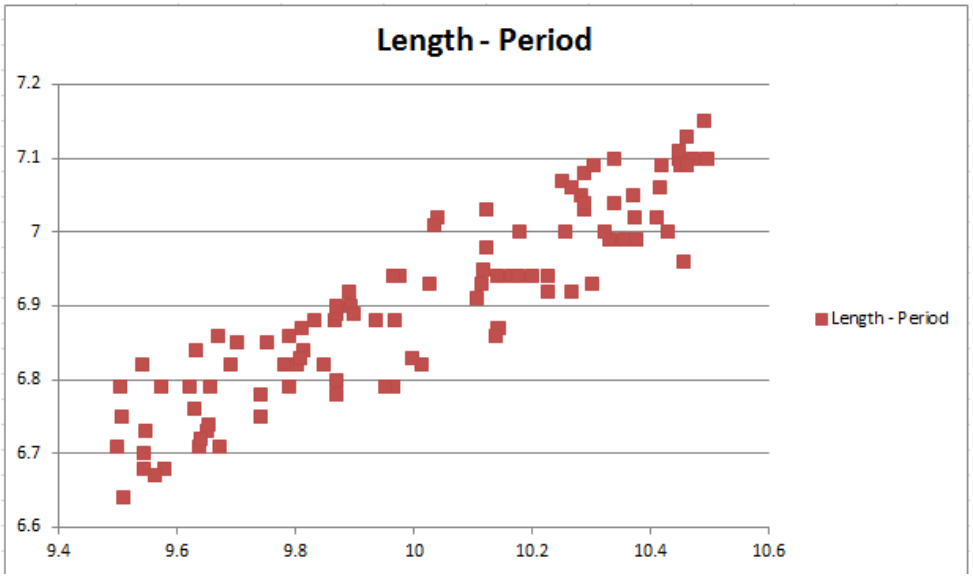
Length = (9.5+1*rand(1))
Theta_Zero = (55+10*rand(1))
ThetaDot_Zero = -(0.25+0.1*rand(1))

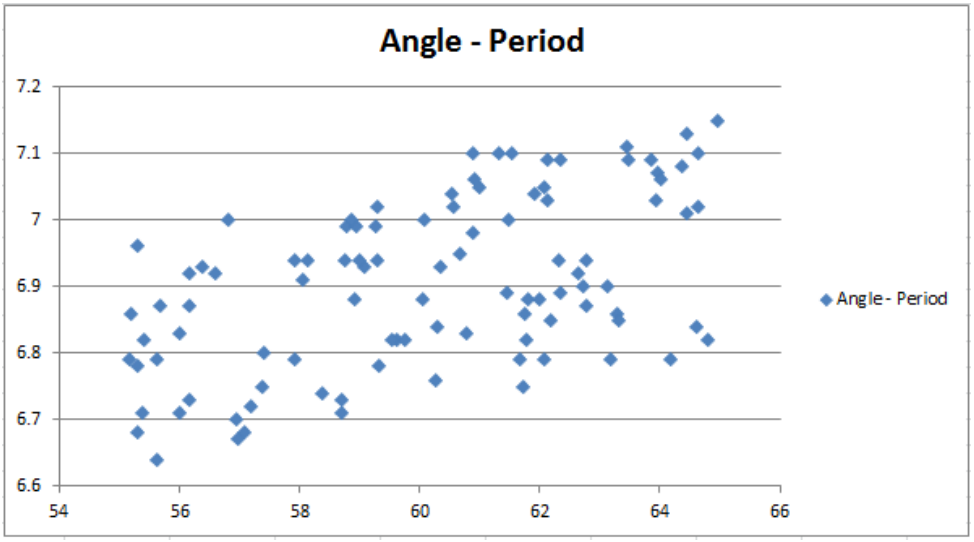
Main code:

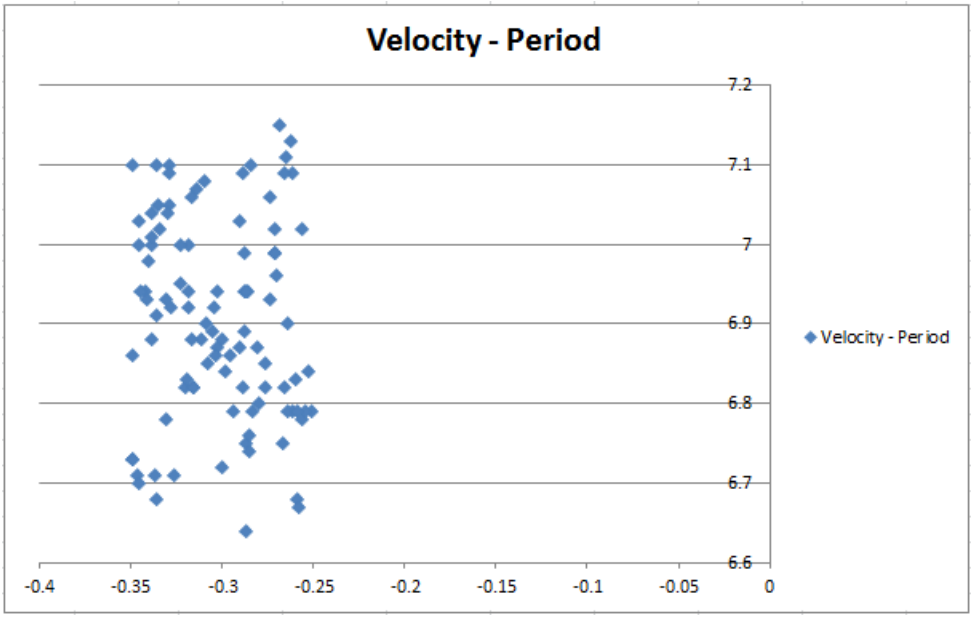
```
/**
 * Start the simulation.
 */
public void start() {
    Random rand = new Random();
    rand.setSeed(System.currentTimeMillis());
    double l = 10; // length
    double r = 1; // the start angle
    double v = 0.3; // the start velocity
    // Do the simulation for a loop.
    for (int i = 0; i < times; i++) {
        // the random variables - normal random.
        l = 9.5 + 1.0 * rand.nextDouble(); // 9.5 - 10.5
        r = 55 + 10 * rand.nextDouble(); // 55 - 65
        r = Math.toRadians(r); // (0.959-1.134)
        v = -(0.25 + 0.1 * rand.nextDouble()); // -(0.25 - 0.35)
        CircusTrapezeImpr ct = new CircusTrapezeImpr(start, end, step, status, method);
        ct.setParameters(l, r, v);
        ct.start();
        // add the data into the list.
        length_list.add(l);
        theta_list.add(r);
        velocity_list.add(v);
        period_list.add(ct.getPeriod());
    }
}
```

Graph:

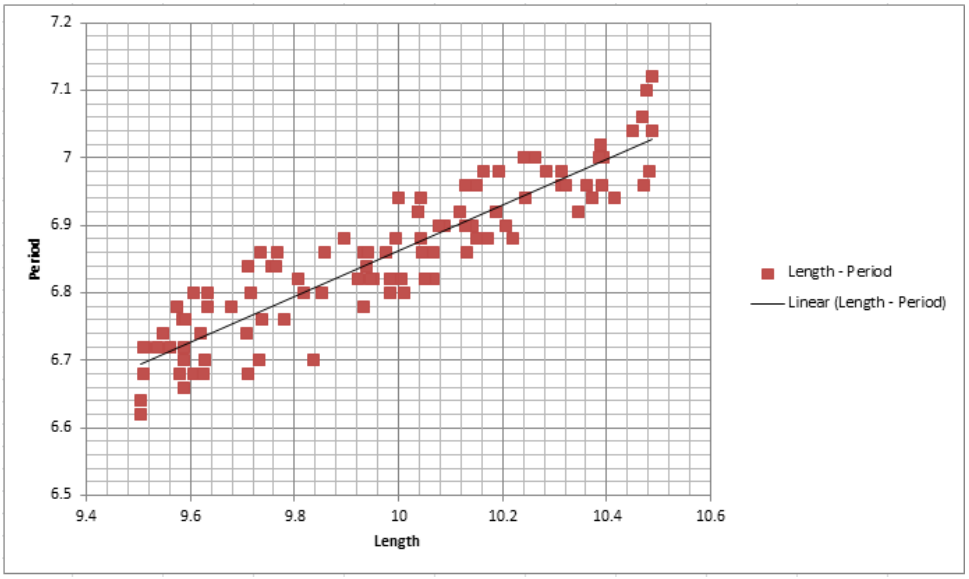
a) EULER:

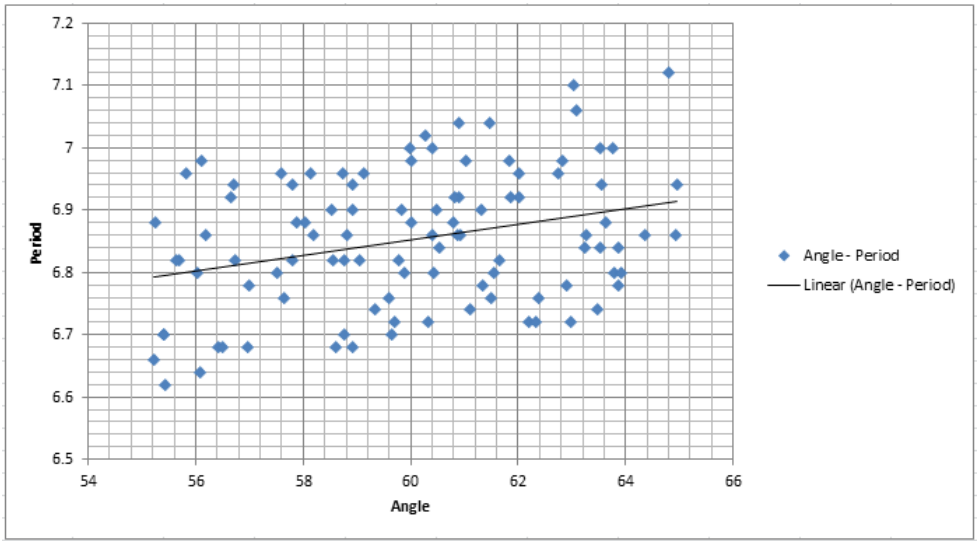


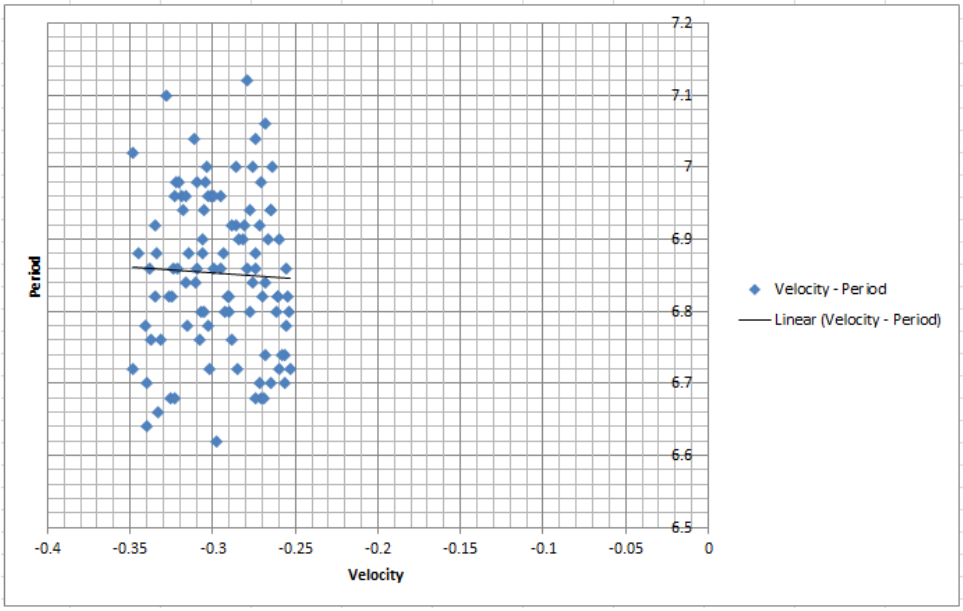




b) RK2:


Period
Length
7.2
7.1
7
6.9
6.8
6.7
6.6
6.5
9.4
9.6
9.8
10
10.2
10.4
10.6
Length - Period
Linear (Length - Period)


Period
Angle
7.2
7.1
7
6.9
6.8
6.7
6.6
6.5
54
56
58
60
62
64
66
Angle - Period
Linear (Angle - Period)


Period
Velocity
7.2
7.1
7
6.9
6.8
6.7
6.6
6.5
-0.4
-0.35
-0.3
-0.25
-0.2
-0.15
-0.1
-0.05
0
Velocity - Period
Linear (Velocity - Period)

Output results:

Test the simulation twice. Show several data at the top and data in the end for the simulations. All the simulation run from 0 to 10s by 0.01s.

a) Euler:

Simulation-0: 10.37543924019524, 58.772234411229185, -0.2710051728726835, 6.99
Simulation-1: 10.300643192430044, 56.391329766488845, -0.2736773273947824, 6.93
Simulation-2: 10.369989541158693, 61.00432927988593, -0.3289737928124982, 7.05
Simulation-3: 9.510747360336945, 55.63475935622401, -0.2868611448873603, 6.64
Simulation-4: 10.448026535050081, 61.54386805160738, -0.34967492166828695, 7.1
Simulation-5: 9.63849516424615, 56.00920889895233, -0.32691220998362397, 6.71
Simulation-6: 9.500006277844317, 58.69002465125784, -0.34625840207887587, 6.71
Simulation-7: 9.848350077500113, 59.60715971835397, -0.2662681147958922, 6.82
Simulation-8: 10.455213490031625, 55.299449633333275, -0.2702761182803464, 6.96
Simulation-9: 10.116522763438134, 60.66525870101228, -0.3229923316074755, 6.95
Simulation-10: 10.141151572749703, 55.69143837919287, -0.30254909739901414, 6.87
.....
Simulation-90: 10.123664010746756, 60.87589715567738, -0.34028435909153276, 6.98
Simulation-91: 9.935526468415427, 60.05269576405984, -0.3164609569742606, 6.88
Simulation-92: 10.419568610181386, 63.47315868699613, -0.2658108292321581, 7.09
Simulation-93: 10.33841615303991, 60.54419058744008, -0.3386600683256655, 7.04
Simulation-94: 9.899520617867452, 61.45545916330392, -0.30574719382730275, 6.89
Simulation-95: 10.034847441639608, 64.43800020334663, -0.33909491428228855, 7.01
Simulation-96: 9.811973724986967, 62.776600422014205, -0.2810473520618786, 6.87
Simulation-97: 9.653079938931768, 58.370828419954634, -0.28508809733312707, 6.74
Simulation-98: 10.121739463349135, 63.93178249895631, -0.34617060188883975, 7.03
Simulation-99: 9.952044621452087, 55.631410014327976, -0.25875973211265013, 6.79

b) RK2:

Simulation-0: 10.036509074048809, 60.903333803579436, -0.3353396155766043, 6.92
Simulation-1: 10.31328100535229, 59.11372602708469, -0.31878817033420254, 6.96
Simulation-2: 9.734850634093618, 64.93079689906371, -0.2794408040874212, 6.86
Simulation-3: 10.18611768528238, 60.828497261881736, -0.2862023820226522, 6.92
Simulation-4: 9.51321634016362, 62.96539329501247, -0.2529945528270978, 6.72
Simulation-5: 9.63400478673774, 63.785325475027534, -0.3070148451448074, 6.8
Simulation-6: 9.632849960579808, 62.89788446312962, -0.34118700572209315, 6.78
Simulation-7: 9.75683662966, 63.23616973458518, -0.3164963055919362, 6.84
Simulation-8: 10.41410817216167, 57.78763073030081, -0.2648804787006988, 6.94
Simulation-9: 10.004799400425345, 58.552781792873226, -0.2697637297968039, 6.82
Simulation-10: 9.76564281199763, 64.36737295555015, -0.32386544371620973, 6.86
.....
Simulation-90: 9.806971541062788, 61.65638659018767, -0.29010397346742184, 6.82
Simulation-91: 9.587131761873461, 55.21949254922478, -0.33291307855224833, 6.66
Simulation-92: 9.81663336654954, 60.43390406677471, -0.2541195414914748, 6.8
Simulation-93: 10.476587487493354, 63.01585056162156, -0.32844513739916875, 7.1
Simulation-94: 10.482331321765562, 56.11444491150223, -0.32104972015061944, 6.98

Simulation-95: 10.12909907852407, 59.82174986077086, -0.2839675890574102, 6.9
Simulation-96: 9.71550374394797, 61.54786530688426, -0.2925834415626492, 6.8
Simulation-97: 9.591053332884595, 61.49396731080539, -0.33174316462279263, 6.76
Simulation-98: 10.391362874164674, 58.12780032677701, -0.32279042016546855, 6.96
Simulation-99: 10.009546091898892, 57.50680289163717, -0.26125810866426846, 6.8

Conclusion:
From the graph and the result, we can see that the period is more correlated with the length than the start angle or the start velocity.

Code:

https://github.com/sampig/SimulationEngineering