Uncertainty Quantification Part I and II of Project

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1 Part 1.1

In our problem we have five input random parameters and we need to evaluate the forces which force1 and force2 when there is no current is induced and in force2 when there is current. In part 1.1 we evaluate the outputs by considering one random variable at time and others are at nominal values. Here, tables are evaluated with 3 samples which shows mean and convergence factor and for histogram plots 10,000 samples have been considered. For part-1 we have considered both distributions normal and uniform.

This section followed the Crude Monte Carlo algorithm which is used to evaluate the output parameters. Then there are tables and histogram plots which show the required results. In the end of this section we present all the answers of the questions which are given in the project.

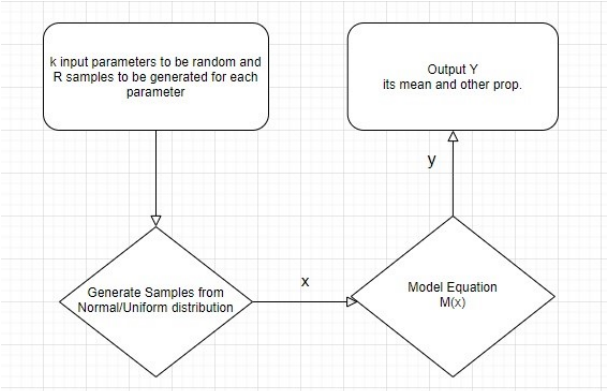


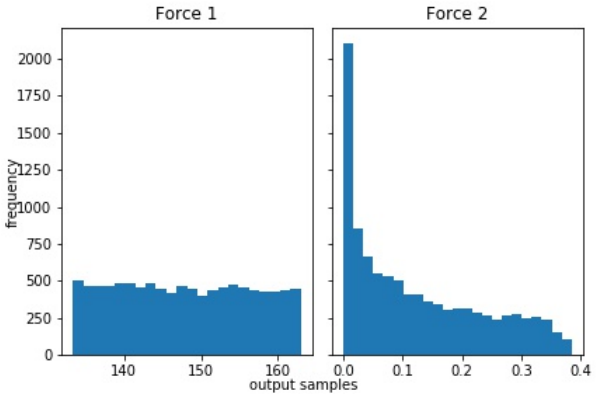
Fig 1: Crude Monte Carlo Algorithm

R	S1	S2	S3	conv
10	145.47128	141.21651	147.55152	2.17319
100	146.73287	148.19167	147.01965	0.74190
1000	147.79215	147.18017	147.43228	0.26031
10,000	147.47139	147.49201	147.47244	0.07859
1,00,000	147.45416	147.45603	147.44131	0.02519
10,00,000	147.42910	147.43368	147.43796	0.00756
50,00,000	147.4316	147.43491	147.43517	0.00356

Table 1: e uniform force 1.

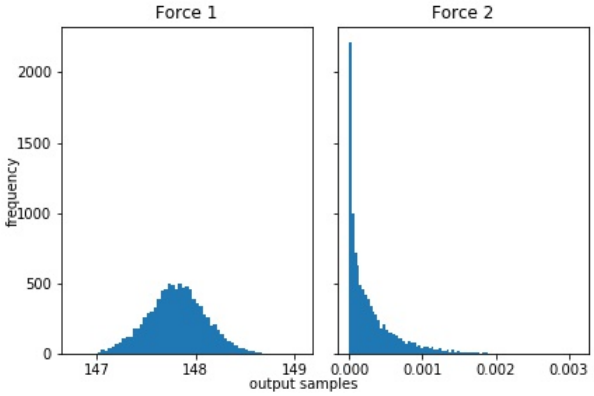
1.1 Is there an Influence on the PDF?

It is clearly seen that in the case of uniform distribution we need a large number of samples for achieving the same value of mean and standard deviation which we can easily achieve in the case of Gaussian distribution for small samples.



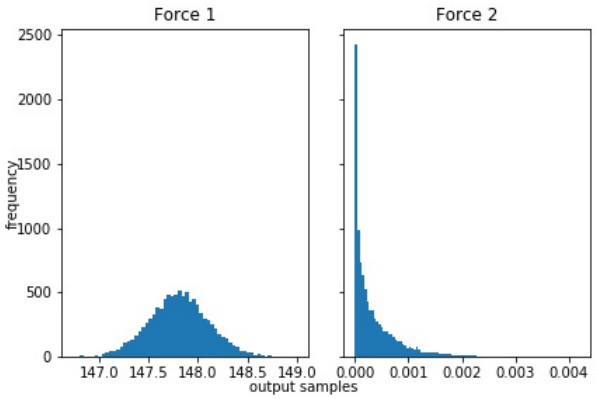
uniform.jpg

Fig 2: br uniform



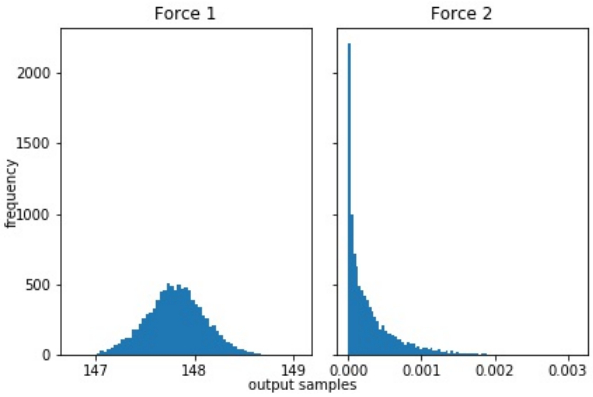
normal.jpg

Fig 3: br normal



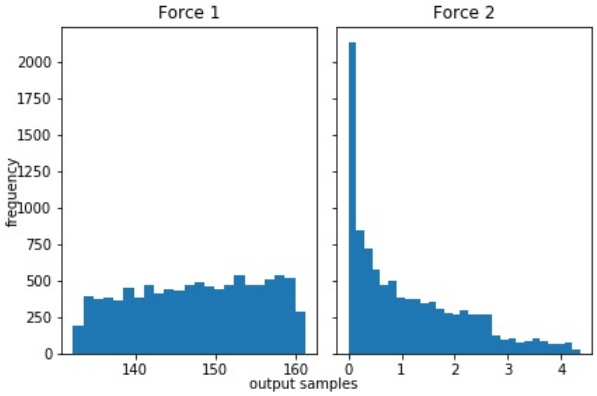
uniform.jpg

Fig 4: haim uniform



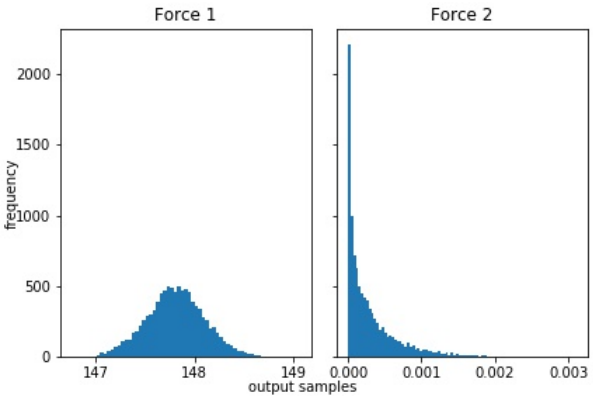
normal.jpg

Fig 5: haim normal



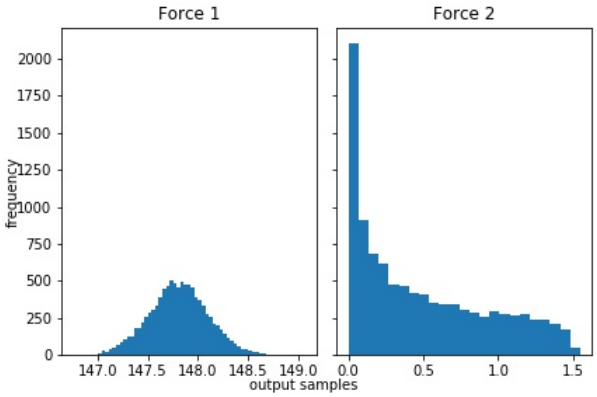
uniform.jpg

Fig 6: e uniform



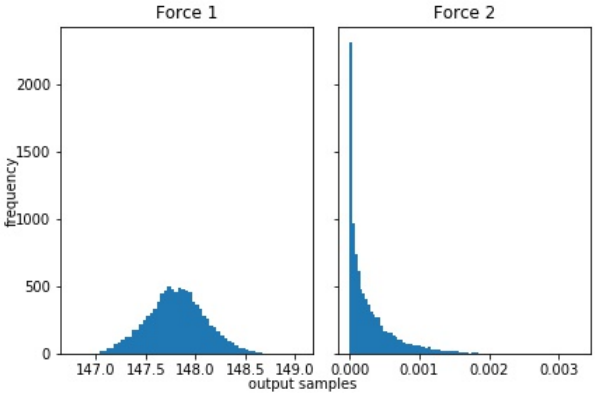
normal.jpg

Fig 7: e normal



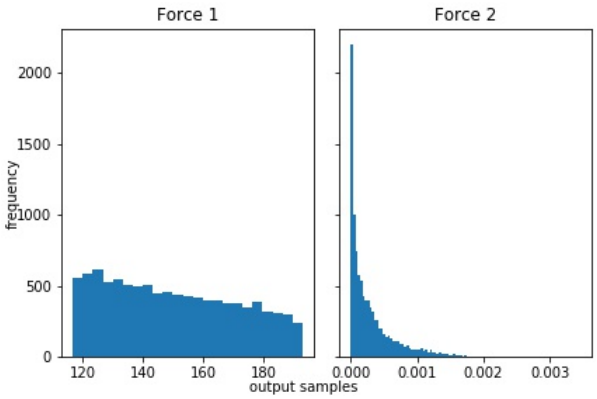
uniform.jpg

Fig 8: current uniform



normal.jpg

Fig 9: current normal



uniform.jpg

Fig 10: ep uniform

R	S1	S2	S3	conv
10	0.96317	1.91256	1.27325	0.27242
100	1.043157	1.01387	1.10226	0.09815
1000	1.23213	1.14142	1.25148	0.03435
10,000	1.15132	1.16586	1.15573	0.01069
1,00,000	1.14974	1.15100	1.15583	0.00341
10,00,000	1.15180	1.149322	1.15175	0.00107
50,00,000	1.15120	1.5156	1.15143	0.00048

Table 2: e uniform force 2.

R	S1	S2	S3	conv
10	145.15426	145.15243	147.23367	2.73554
100	147.61098	147.29140	147.75053	0.85730
1000	147.56448	147.50475	148.125120	0.27413
10,000	148.05317	148.0143	147.61236	0.08542
1,00,000	147.94739	147.94933	147.91914	0.02698
10,00,000	147.93912	147.9414	147.92255	0.00853
50,00,000	147.93155	147.92565	147.92397	0.00381

Table 3: br uniform force 1.

normal.jpg

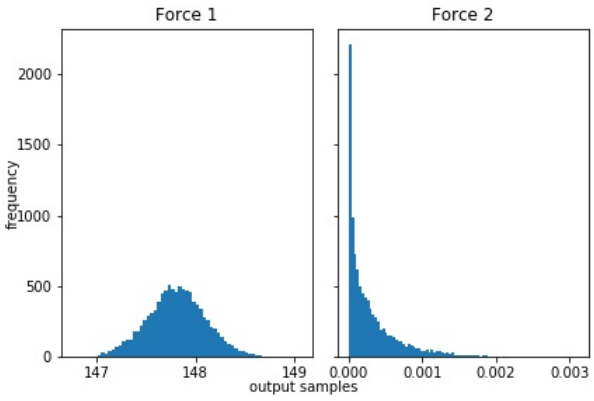


Fig 11: ep normal

1.2 1.1.4 Which value seems to be most influent on force 1 and force 2

The random variable ep parameter has most influence on force1 and the random variable e has most influence on force 2. Hence in Part II we will only consider ep and e as single random variables other than all 5 combined case.

2 Part 1.2

In part I.II we consider all 5 input parameters are random.

2.1 Comparison with case 1

The comparison between the two cases clearly illustrate that in case1 the uncertainty is much more than case 2. The values in case 1 are much closer to the deterministic case as compared to case2.

random uniform.jpg

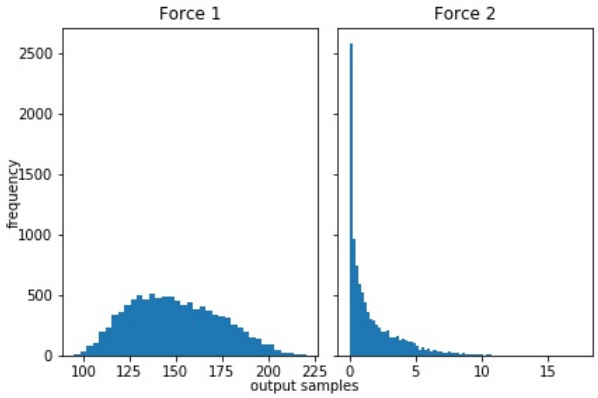


Fig 12: All random uniform

random normal.jpg

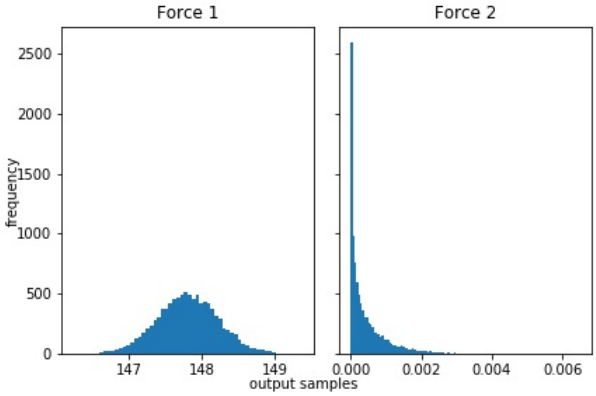


Fig 13: All random normal

R	S1	S2	S3	conv
10	0.14256	0.14916	0.17814	0.22401
100	0.13515	0.10507	0.12475	0.01150
1000	0.11794	0.12011	0.012696	0.00340
10,000	0.12457	0.12436	0.00110	0.12263
1,00,000	0.12288	0.12327	0.12336	0.00034
10,00,000	0.12326	0.12325	0.12333	0.00011
50,00,000	0.12334	0.12343	0.12337	4.9e-5

Table 4: br uniform force 2.

R	S1	S2	S3	conv
10	147.51056	133.01096	141.68261	6.3e-06
100	149.87327	149.07359	153.85526	2.3e-06
1000	149.07601	150.71015	150.74356	7.3e-07
10,000	150.81391	149.36744	149.47618	0.21520
1,00,000	150.04071	150.02993	150.12318	0.06780
10,00,000	150.04350	150.03806	150.05047	0.02146
50,00,000	150.09124	150.07137	150.06876	0.00960

Table 5: ep uniform force 1.

2.2 Comment on convergence speed when increasing RV from 1 to 5

The effect of random variables on the speed of convergence is none because it is a property of the Crude Monte Carlo method that its convergence is not affected related to the number of random variables. Its convergence speed is very very slow.

3 part 2

In this part we have to evaluate the probabilities that F1 is lower than 120, F2 is greater than 10 and both.

We dealt with three cases ep, e and all input as random variables. Last 9 tables of the report correspond to Part II of the project.

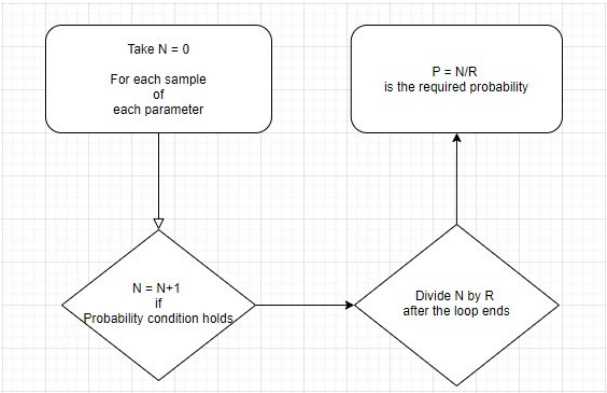


Fig 14: Algorithm to calculate Probability

R	S1	S2	S3	conv
10	0.00016	0.00014	0.00015	6.4e-06
100	0.00016	0.00015	0.00016	2.3e-06
1000	0.00016	0.00016	0.00016	7.3e-07
10,000	0.00016	0.00016	0.00016	2.3e-07
1,00,000	0.00016	0.00016	0.00016	7.2e-08
10,00,000	0.00016	0.00016	0.00016	2.3e-08
50,00,000	0.00016	0.00016	0.00016	1.03e-08

Table 6: ep uniform force 2.

R	S1	S2	S3	conv
10	147.79844	147.80413	147.97000	0.13644
100	147.79395	147.79228	147.80432	0.00514
1000	147.80183	147.80129	147.80479	0.00181
10,000	147.80235	147.80225	147.80179	0.00057
1,00,000	147.80270	147.80305	147.80264	0.00018
10,00,000	147.80266	147.80276	147.80256	5.7e-05
50,00,000	147.80277	147.80280	147.80281	2.5e-05

Table 7: haim uniform force 1.

R	S1	S2	S3	conv
10	0.00021	0.00024	0.00038	4.2e-05
100	0.00024	0.00024	0.00022	2.0e-05
1000	0.00023	0.00022	0.00021	6.5e-06
10,000	0.00022	0.00022	0.00022	2.0e-06
1,00,000	0.00022	0.00022	0.00022	6.5e-07
10,00,000	0.00022	0.00022	0.00022	2.0e-07
50,00,000	0.00022	0.00022	0.00022	9.2e-08

Table 8: haim uniform force 2.

R	S1	S2	S3	conv
10	0.64506	0.43502	0.33597	0.31095
100	0.49582	0.52290	0.50459	0.04512
1000	0.49553	0.57332	0.50359	0.01397
10000	0.49069	0.49379	0.49120	0.0044
1,00,000	0.49377	0.49452	0.49457	0.00140
10,00,000	0.49398	0.49371	0.49377	0.00044
50,00,000	0.49420	0.49372	0.49403	0.00019

Table 9: current uniform force 2.

R	S1	S2	S3	conv
10	147.75827	147.72617	147.87282	0.09817
100	147.78063	147.81671	147.81825	0.03101
1000	147.81946	147.80453	147.83223	0.00883
10,000	147.80591	147.80495	147.80501	0.00296
1,00,000	147.80531	147.80487	147.80422	0.00093
10,00,000	147.80425	147.8043	147.80453	0.00029
50,00,000	147.80451	147.80467	147.80459	0.00013

Table 10: br normal force 1.

R	S1	S2	S3	conv
10	0.00035	0.00039	0.00037	0.00011
100	0.00033	0.00029	0.00027	3.90e-05
1000	0.00028	0.00029	0.00027	1.08e-05
10000	0.0003	0.0003	0.0003	3.60e-06
100000	0.0003	0.0003	0.0003	1.10e-06
1000000	0.0003	0.0003	0.0003	3.70e-07
5000000	0.0003	0.0003	0.0003	1.60e-07

Table 11: br normal force 2.

R	S1	S2	S3	conv
10	147.80432	147.80442	147.80456	9.80e-05
100	147.80432	147.80432	147.80432	3.10e-05
1000	147.80431	147.80442	147.80487	1.00e-05
10000	147.80442	147.80441	147.80443	3.40e-06
100000	147.80442	147.80442	147.80442	1.00e-06
1000000	147.80442	147.80442	147.80442	3.40e-07
5000000	147.80442	147.80442	147.80442	1.50e-07

Table 12: e normal force 1.

R	S1	S2	S3	conv
10	0.00015	0.00015	0.00015	3.30e-07
100	0.00015	0.00015	0.00015	1.00e-07
1000	0.00015	0.00015	0.00015	3.50e-08
10000	0.00015	0.00015	0.00015	1.10e-08
100000	0.00015	0.00015	0.00015	3.60e-09
1000000	0.00015	0.00015	0.00015	1.10e-09
5000000	0.00015	0.00015	0.00015	5.17e-10

Table 13: e normal force 2.

R	S1	S2	S3	conv
10	147.80445	147.80451	147.80467	6.20e-05
100	147.80441	147.80442	147.80443	2.60e-05
1000	147.80442	147.80442	147.80442	7.60e-06
10000	147.80442	147.80442	147.80442	2.40e-06
100000	147.80442	147.80442	147.80442	7.60e-07
1000000	147.80442	147.80442	147.80442	2.40e-07
5000000	147.80442	147.80442	147.80442	1.00e-07

Table 14: ep normal force 1.

R	S1	S2	S3	conv
10	0.00015	0.00015	0.00015	6.70e-11
100	0.00015	0.00015	0.00015	2.80e-11
1000	0.00015	0.00015	0.00015	8.20e-12
10000	0.00015	0.00015	0.00015	2.60e-12
100000	0.00015	0.00015	0.00015	8.19e-13
1000000	0.00015	0.00015	0.00015	2.59e-13
5000000	0.00015	0.00015	0.00015	1.16e-13

Table 15: ep normal force 2.

R	S1	S2	S3	conv
10	147.80446	147.80451	147.80467	5.16e-05
100	147.80441	147.8044	147.80443	1.70e-06
1000	147.80442	147.80442	147.80442	5.16e-07
10000	147.80442	147.80442	147.80442	1.60e-07
100000	147.80442	147.80442	147.80442	5.20e-08
1000000	147.80442	147.80442	147.80442	1.60e-08
5000000	147.80442	147.80442	147.80442	7.30e-09

Table 16: haim normal force 1.

R	S1	S2	S3	conv
10	0.00015	0.00015	0.00015	1.70e-08
100	0.00015	0.00015	0.00015	5.80e-09
1000	0.00015	0.00015	0.00015	1.70e-09
10000	0.00015	0.00015	0.00015	5.50e-10
100000	0.00015	0.00015	0.00015	1.70e-10
1000000	0.00015	0.00015	0.00015	5.50e-11
5000000	0.00015	0.00015	0.00015	2.40e-11

Table 17: haim normal force 2.

R	S1	S2	S3	conv
10	0.00015	0.00015	0.00015	1.70e-07
100	0.00015	0.00015	0.00015	3.90e-08
1000	0.00015	0.00015	0.00015	1.20e-08
10000	0.00015	0.00015	0.00015	3.80e-09
100000	0.00015	0.00015	0.00015	1.20e-09
1000000	0.00015	0.00015	0.00015	3.90e-10
5000000	0.00015	0.00015	0.00015	1.70e-10

Table 18: current normal force 2.

R	S1	S2	S3	conv
10	151.99165	160.32926	140.91721	7.36256
100	150.35774	151.69125	150.83038	2.43098
1000	150.70704	149.86512	150.0672	0.75865
10000	149.52385	149.79439	150.03615	0.24487
100000	149.92523	149.83358	149.93442	0.07736
1000000	149.80654	149.84531	149.81789	0.02443
5000000	149.83306	149.83605	149.83545	0.01093

Table 19: all random uniform force 1.

R	S1	S2	S3	conv
10	1.0232	1.27794	1.57816	0.39844
100	1.82531	1.89108	1.65273	0.21315
1000	1.78519	1.97454	1.72191	0.06974
10000	1.77449	1.80182	1.80253	0.02175
100000	1.80673	1.79435	1.80919	0.00700
1000000	1.80056	1.80678	1.80138	0.00221
5000000	1.80093	1.80228	1.80312	0.00099

Table 20: all random uniform force 2.

R	S1	S2	S3	conv
10	147.71785	147.72287	147.83395	0.07645
100	147.73095	147.85211	147.82285	0.02851
1000	147.79485	147.80893	147.8025	0.00952
10000	147.81145	147.80412	147.80718	0.00301
100000	147.80289	147.80658	147.80638	0.00093
1000000	147.80473	147.80499	147.80469	0.00029
5000000	147.80431	147.80453	147.80476	0.00013

Table 21: all random gaussian force 1.

R	S1	S2	S3	conv
10	0.00035	0.00025	0.00027	0.00013
100	0.00038	0.00026	0.00028	3.90e-05
1000	0.00032	0.00029	0.0003	1.20e-05
10000	0.00031	0.0003	0.0003	3.80e-06
100000	0.0003	0.0003	0.0003	1.10e-06
1000000	0.0003	0.0003	0.0003	3.70e-07
5000000	0.0003	0.0003	0.0003	1.60e-07

Table 22: all random gaussian force 2.

R	S1	S2	S3	conv
10	0	0	0	0
100	0.09	0.09	0.07	0.02861
1000	0.058	0.062	0.061	0.00739
10000	0.0526	0.0524	0.0541	0.00223
100000	0.05474	0.05367	0.05282	0.00071
1000000	0.05314	0.05347	0.05321	0.00022
5000000	0.05326	0.05324	0.05323	0.0001

Table 23: ep as random force 1 proba

R	S1	S2	S3	conv
10	0	0	0	0
100	0	0	0	0
1000	0	0	0	0
10000	0	0	0	0
100000	0	0	0	0
1000000	0	0	0	0
5000000	0	0	0	0

Table 24: ep as random force 2 proba

R	S1	S2	S3	conv
10	0	0	0	0
100	0.08	0.08	0.07	0.02851
1000	0.058	0.062	0.061	0.00739
10000	0.0526	0.0524	0.0541	0.00223
100000	0.05474	0.05367	0.05282	0.00071
1000000	0.05314	0.05347	0.05321	0.00022
5000000	0.05326	0.05324	0.05323	0.0001

Table 25: ep as random force 1 or force2 proba

R	S1	S2	S3	conv
10	0	0	0	0
100	0	0	0	0
1000	0	0	0	0
10000	0	0	0	0
100000	0	0	0	0
1000000	0	0	0	0
5000000	0	0	0	0

Table 26: e as random force 1 proba

R	S1	S2	S3	conv
10	0	0	0	0
100	0	0	0	0
1000	0	0	0	0
10000	0	0	0	0
100000	0	0	0	0
1000000	0	0	0	0
5000000	0	0	0	0

Table 27: e as random force 2 proba

R	S1	S2	S3	conv
10	0	0	0	0
100	0	0	0	0
1000	0	0	0	0
10000	0	0	0	0
100000	0	0	0	0
1000000	0	0	0	0
5000000	0	0	0	0

Table 28: e as random force 1 or force 2 proba

R	S1	S2	S3	conv
10	0.5	0.1	0	0.15811
100	0.11	0.13	0.09	0.03128
1000	0.123	0.115	0.108	0.01038
10000	0.103	0.105	0.1065	0.00303
100000	0.11271	0.1104	0.1117	0.001
1000000	0.11109	0.11065	0.11116	0.00031
5000000	0.11115	0.11111	0.11111	0.00014

Table 29: all parameters are random force1 proba

R	S1	S2	S3	conv
10	0.1	0	0	0.09486
100	0.02	0	0.01	0.014
1000	0.005	0.008	0.005	0.00223
10000	0.0091	0.0105	0.0093	0.00094
100000	0.00956	0.00929	0.0096	0.0003
1000000	0.00929	0.00922	0.00942	9.50e-05
5000000	0.00918	0.0092	0.00923	4.20e-05

Table 30: all parameters are random force2 proba

R	S1	S2	S3	conv
10	0.5	0.1	0	0.15715
100	0.12	0.13	0.1	0.03245
1000	0.128	0.121	0.112	0.01564
10000	0.1112	0.1145	0.115	0.00314
100000	0.12107	0.11875	0.12018	0.00103
1000000	0.11937	0.11876	0.11948	0.00102
5000000	0.11955	0.1193	0.11931	0.00014

Table 31: all parameters are random force1 or force 2 proba