

Applied Mathematics 30 Student Project: Medical Research: Huntington's Disease

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Huntington's disease (HD) is a neurological disease characterized by movement disorder, dementia and psychiatric disturbances. A single abnormal or mutated gene produces HD. The impact of a gene depends partly on whether it is dominant or recessive. If a gene is dominant, only one of the paired chromosomes is required to produce HD's effect. HD is autosomal dominant, which means that only one copy of the defective gene, inherited from either parent, is needed to produce the disease.

Part A

- In addition to the terms introduced, the following terms will also help in completing this project:

Punnet square: a chart showing the possible combinations of alleles in offspring.

Heterozygous: a person who has one or more pairs of unlike genes.

Homozygous: a person possessing like pairs of genes for any hereditary characteristics.

Huntington's disease: a neurological disease that is produced by an abnormal gene.

- A couple, of which one is heterozygous for the HD gene, is planning to have children.
 - Construct the sample space (Punnet square) for possible offspring of this couple.

	H	h
h	hH	hh
h	hH	hh

- What is the probability that this couple will have a child who has HD?
 $\frac{2}{4} = \frac{1}{2}$ or 50%
 Therefore, there is a 50 percent chance that the child will have HD.
- If this couple were to have three children, what would be the probability that at least one of the children would have HD?
 $\text{Binompdf}(3, 0.50) = (.125, .375, .375, .125)$
 $P = (1 \text{ or } 2 \text{ or } 3) = .375/1 + .375/2 + .375/3 = .875$ or 85%
 Therefore, the probability that at least one child will have HD is 85 percent.

- A different couple, both of whom are heterozygous for the HD gene, is planning to have children.
 - Construct the sample space (Punnet square) for possible offspring of this couple.

	H	h
H	HH	Hh
h	hH	hh

- What is the probability that these parents will have a child who has HD?
 $\frac{3}{4}$ or 75%
 There is a 75 percent chance that the child will have HD.
 - If this couple were to have three children, what would be the probability that none of the children would have HD?
 $\text{Binompdf}(3, 0.75) = 9.015625, .140625, .421875, .421875)$
 $P(0) = .015625$ or 1.6%
 Therefore, the probability that none of the children will have HD is 1.6 percent.
- A sample of 1,007 people was taken. Each person has only one parent who is heterozygous for the HD gene. Construct the symmetric 95 percent confidence interval for the number of people who would have HD in this sample.

$$\text{Mean} = \mu = n \times p$$

$$\mu = 1,007 \times 0.50$$

$$\mu = 503.5$$

$$\text{Standard Deviation} = \sigma = \sqrt{n \times p(1 - P)}$$

$$\sigma = \sqrt{(1,007 \times 0.50 \times (1 - 0.50))}$$

$$\sigma = 15.9$$

$$95\% \text{ confidence interval is } \pm 1.96\sigma$$

$$\text{Lower bound} = \mu - 1.96\sigma$$

$$= 503.5 - 1.96(15.9)$$

$$= 472.3$$

$$\text{Upper bound} = \mu + 1.96\sigma$$

$$= 503.5 + 1.96(15.9)$$

$$= 534.7$$

Therefore, with the 95 percent confidence interval, we know that between 472 and 535 of the 1,007 people will have HD.

Most patients with HD take medication on a regular basis. The patient's body excretes the medication at a certain rate. If the patient takes the medication as prescribed, over time the amount of medication in the body will be maintained at a constant level.

Part B

1. A doctor prescribes 16 ml of medication to a certain patient to be taken every four hours over

an extended period of time. The patient's body excretes 25 percent of the amount of the medication every four hours. Show the amount of medication that remains in the body after each dose by constructing a spreadsheet or by producing a table with your graphing calculator. Use four decimal places for any columns that contain decimal values. Extend your spreadsheet until it shows that the total amount of medication in the body is maintained at a relatively constant level.

Part B #1				
Time (hr)	Amount Excreted (ml)	Residual Amount (ml)	Dosage (ml)	Total Amount in the Body (ml)
0	0.0000	0.0000	16.0000	16.0000
4	4.0000	12.0000	16.0000	28.0000
8	7.0000	21.0000	16.0000	37.0000
12	9.2500	27.7500	16.0000	43.7500
16	10.9375	32.8125	16.0000	48.8125
20	12.2031	36.6094	16.0000	52.6094
24	13.1523	39.4570	16.0000	55.4570
28	13.8643	41.5928	16.0000	57.5928
32	14.3982	43.1946	16.0000	59.1946
36	14.7986	44.3959	16.0000	60.3959
40	15.0990	45.2970	16.0000	61.2970
44	15.3242	45.9727	16.0000	61.9727
48	15.4932	46.4795	16.0000	62.4795
52	15.6199	46.8597	16.0000	62.8597
56	15.7149	47.1447	16.0000	63.1447
60	15.7862	47.3586	16.0000	63.3586
64	15.8396	47.5189	16.0000	63.5189
68	15.8797	47.6392	16.0000	63.6392
72	15.9098	47.7294	16.0000	63.7294
76	15.9323	47.7970	16.0000	63.7970
80	15.9493	47.8478	16.0000	63.8478
84	15.9619	47.8858	16.0000	63.8858
88	15.9715	47.9144	16.0000	63.9144
92	15.9786	47.9358	16.0000	63.9358
96	15.9839	47.9518	16.0000	63.9518
100	15.9880	47.9639	16.0000	63.9639
104	15.9910	47.9729	16.0000	63.9729
108	15.9932	47.9797	16.0000	63.9797
112	15.9949	47.9848	16.0000	63.9848
116	15.9962	47.9886	16.0000	63.9886
120	15.9971	47.9914	16.0000	63.9914
124	15.9979	47.9936	16.0000	63.9936
128	15.9984	47.9952	16.0000	63.9952
132	15.9988	47.9964	16.0000	63.9964
136	15.9991	47.9973	16.0000	63.9973
140	15.9993	47.9980	16.0000	63.9980
144	15.9995	47.9985	16.0000	63.9985

148	15.9996	47.9989	16.0000	63.9989
152	15.9997	47.9991	16.0000	63.9991
156	15.9998	47.9994	16.0000	63.9994
160	15.9998	47.9995	16.0000	63.9995
164	15.9999	47.9996	16.0000	63.9996
168	15.9999	47.9997	16.0000	63.9997
172	15.9999	47.9998	16.0000	63.9998
176	15.9999	47.9998	16.0000	63.9998
180	16.0000	47.9999	16.0000	63.9999
184	16.0000	47.9999	16.0000	63.9999
188	16.0000	47.9999	16.0000	63.9999
192	16.0000	48.0000	16.0000	64.0000
196	16.0000	48.0000	16.0000	64.0000
200	16.0000	48.0000	16.0000	64.0000
204	16.0000	48.0000	16.0000	64.0000
208	16.0000	48.0000	16.0000	64.0000
212	16.0000	48.0000	16.0000	64.0000
216	16.0000	48.0000	16.0000	64.0000
220	16.0000	48.0000	16.0000	64.0000
224	16.0000	48.0000	16.0000	64.0000
228	16.0000	48.0000	16.0000	64.0000
232	16.0000	48.0000	16.0000	64.0000
236	16.0000	48.0000	16.0000	64.0000
240	16.0000	48.0000	16.0000	64.0000

2. When does the total amount of medication in the patient's body appear to level off? What amount of medication is in the patient's body at this point? Explain your answer.

The total amount of medication in the patient's body levels off after 192 hours. The amount of

medication in the patient's body is 64.0000 ml. This is because of a balanced dose and excretion.

3. If the patient forgets to take one dose of the medication in the first 36 hours, what would the effect be on the level of medication in the patient's body?

Part B #3a

Time (hr)	Amount Excreted (ml)	Residual Amount (ml)	Dosage (ml)	Total Amount in the Body (ml)
0	0.0000	0.0000	16.0000	16.0000
4	4.0000	12.0000	16.0000	28.0000
8	7.0000	21.0000	16.0000	37.0000
12	9.2500	27.7500	16.0000	43.7500
16	10.9375	32.8125	16.0000	48.8125
20	12.2031	36.6094	16.0000	52.6094
24	13.1523	39.4570	16.0000	55.4570
28	13.8643	41.5928	16.0000	57.5928
32	14.3982	43.1946	16.0000	59.1946
36	14.7986	44.3959	0.0000	44.3959
40	11.0990	33.2970	16.0000	49.2970
44	12.3242	36.9727	16.0000	52.9727
48	13.2432	39.7295	16.0000	55.7295
52	13.9324	41.7972	16.0000	57.7972

56	14.4493	43.3479	16.0000	59.3479
60	14.8370	44.5109	16.0000	60.5109
64	15.1277	45.3832	16.0000	61.3832
68	15.3458	46.0374	16.0000	62.0374
72	15.5093	46.5280	16.0000	62.5280
76	15.6320	46.8960	16.0000	62.8960
80	15.7240	47.1720	16.0000	63.1720
84	15.7930	47.3790	16.0000	63.3790
88	15.8448	47.5343	16.0000	63.5343
92	15.8836	47.6507	16.0000	63.6507
96	15.9127	47.7380	16.0000	63.7380
100	15.9345	47.8035	16.0000	63.8035
104	15.9509	47.8526	16.0000	63.8526
108	15.9632	47.8895	16.0000	63.8895
112	15.9724	47.9171	16.0000	63.9171
116	15.9793	47.9378	16.0000	63.9378
120	15.9845	47.9534	16.0000	63.9534
124	15.9883	47.9650	16.0000	63.9650
128	15.9913	47.9738	16.0000	63.9738
132	15.9934	47.9803	16.0000	63.9803
136	15.9951	47.9852	16.0000	63.9852
140	15.9963	47.9889	16.0000	63.9889
144	15.9972	47.9917	16.0000	63.9917
148	15.9979	47.9938	16.0000	63.9938
152	15.9984	47.9953	16.0000	63.9953
156	15.9988	47.9965	16.0000	63.9965
160	15.9991	47.9974	16.0000	63.9974
164	15.9993	47.9980	16.0000	63.9980
168	15.9995	47.9985	16.0000	63.9985
172	15.9996	47.9989	16.0000	63.9989
176	15.9997	47.9992	16.0000	63.9992
180	15.9998	47.9994	16.0000	63.9994
184	15.9998	47.9995	16.0000	63.9995
188	15.9999	47.9996	16.0000	63.9996
192	15.9999	47.9997	16.0000	63.9997
196	15.9999	47.9998	16.0000	63.9998
200	16.0000	47.9999	16.0000	63.9999
204	16.0000	47.9999	16.0000	63.9999
208	16.0000	47.9999	16.0000	63.9999
212	16.0000	47.9999	16.0000	63.9999
216	16.0000	48.0000	16.0000	64.0000
220	16.0000	48.0000	16.0000	64.0000
224	16.0000	48.0000	16.0000	64.0000
228	16.0000	48.0000	16.0000	64.0000
232	16.0000	48.0000	16.0000	64.0000
236	16.0000	48.0000	16.0000	64.0000
240	16.0000	48.0000	16.0000	64.0000

If the patient forgot to take the medication within the first 36 hours, the level of medication in his body would only be 63.9996 ml instead of 64.0000 ml after 192 hours, and the medication would not level off at 64.0000 ml until 216 hours.

If the patient forgets to take one dose of the medication sometime on the sixth day, what would the effect be on the level of medication in the patient's body?

Part B 3b

Time (hr)	Amount Excreted (ml)	Residual Amount (ml)	Dosage (ml)	Total Amount in the Body (ml)
0	0.0000	0.0000	16.0000	16.0000
4	4.0000	12.0000	16.0000	28.0000
8	7.0000	21.0000	16.0000	37.0000
12	9.2500	27.7500	16.0000	43.7500
16	10.9375	32.8125	16.0000	48.8125
20	12.2031	36.6094	16.0000	52.6094
24	13.1523	39.4570	16.0000	55.4570
28	13.8643	41.5928	16.0000	57.5928
32	14.3982	43.1946	16.0000	59.1946
36	14.7986	44.3959	16.0000	60.3959
40	15.0990	45.2970	16.0000	61.2970
44	15.3242	45.9727	16.0000	61.9727
48	15.4932	46.4795	16.0000	62.4795
52	15.6199	46.8597	16.0000	62.8597
56	15.7149	47.1447	16.0000	63.1447
60	15.7862	47.3586	16.0000	63.3586
64	15.8396	47.5189	16.0000	63.5189
68	15.8797	47.6392	16.0000	63.6392
72	15.9098	47.7294	16.0000	63.7294
76	15.9323	47.7970	16.0000	63.7970
80	15.9493	47.8478	16.0000	63.8478
84	15.9619	47.8858	16.0000	63.8858
88	15.9715	47.9144	16.0000	63.9144
92	15.9786	47.9358	16.0000	63.9358
96	15.9839	47.9518	16.0000	63.9518
100	15.9880	47.9639	16.0000	63.9639
104	15.9910	47.9729	16.0000	63.9729
108	15.9932	47.9797	16.0000	63.9797
112	15.9949	47.9848	16.0000	63.9848
116	15.9962	47.9886	16.0000	63.9886
120	15.9971	47.9914	16.0000	63.9914
124	15.9979	47.9936	16.0000	63.9936
128	15.9984	47.9952	0.0000	47.9952
132	11.9988	35.9964	16.0000	51.9964
136	12.9991	38.9973	16.0000	54.9973
140	13.7493	41.2480	16.0000	57.2480
144	14.3120	42.9360	16.0000	58.9360
148	14.7340	44.2020	16.0000	60.2020
152	15.0505	45.1515	16.0000	61.1515
156	15.2879	45.8636	16.0000	61.8636
160	15.4659	46.3977	16.0000	62.3977
164	15.5994	46.7983	16.0000	62.7983
168	15.6996	47.0987	16.0000	63.0987
172	15.7747	47.3240	16.0000	63.3240
176	15.8310	47.4930	16.0000	63.4930
180	15.8733	47.6198	16.0000	63.6198
184	15.9049	47.7148	16.0000	63.7148
188	15.9287	47.7861	16.0000	63.7861
192	15.9465	47.8396	16.0000	63.8396

196	15.9599	47.8797	16.0000	63.8797
200	15.9699	47.9098	16.0000	63.9098
204	15.9774	47.9323	16.0000	63.9323
208	15.9831	47.9492	16.0000	63.9492
212	15.9873	47.9619	16.0000	63.9619
216	15.9905	47.9715	16.0000	63.9715
220	15.9929	47.9786	16.0000	63.9786
224	15.9946	47.9839	16.0000	63.9839
228	15.9960	47.9880	16.0000	63.9880
232	15.9970	47.9910	16.0000	63.9910
236	15.9977	47.9932	16.0000	63.9932
240	15.9983	47.9949	16.0000	63.9949

If the patient forgets to take the medication on the sixth day, the level of medication in his body would only be 63.8396 ml instead of 64.0000 ml after 192 hours.

4. After 10 days, the method of treatment is changed, but before a new treatment can be

started, all of the current medication must be excreted from the patient's body. Use a spreadsheet or your graphing calculator to determine the amount of time it will take, to the nearest day, for the patient's body to excrete all the medication. Show how you determine this answer and justify it.

Part B #4

Time (hr)	Amount Excreted (ml)	Residual Amount (ml)	Dosage (ml)	Total Amount in the Body (ml)
0	0.0000	0.0000	16.0000	16.0000
4	4.0000	12.0000	16.0000	28.0000
8	7.0000	21.0000	16.0000	37.0000
12	9.2500	27.7500	16.0000	43.7500
16	10.9375	32.8125	16.0000	48.8125
20	12.2031	36.6094	16.0000	52.6094
24	13.1523	39.4570	16.0000	55.4570
28	13.8643	41.5928	16.0000	57.5928
32	14.3982	43.1946	16.0000	59.1946
36	14.7986	44.3959	16.0000	60.3959
40	15.0990	45.2970	16.0000	61.2970
44	15.3242	45.9727	16.0000	61.9727
48	15.4932	46.4795	16.0000	62.4795
52	15.6199	46.8597	16.0000	62.8597
56	15.7149	47.1447	16.0000	63.1447
60	15.7862	47.3586	16.0000	63.3586
64	15.8396	47.5189	16.0000	63.5189
68	15.8797	47.6392	16.0000	63.6392
72	15.9098	47.7294	16.0000	63.7294
76	15.9323	47.7970	16.0000	63.7970
80	15.9493	47.8478	16.0000	63.8478
84	15.9619	47.8858	16.0000	63.8858
88	15.9715	47.9144	16.0000	63.9144
92	15.9786	47.9358	16.0000	63.9358
96	15.9839	47.9518	16.0000	63.9518
100	15.9880	47.9639	16.0000	63.9639

104	15.9910	47.9729	16.0000	63.9729
108	15.9932	47.9797	16.0000	63.9797
112	15.9949	47.9848	16.0000	63.9848
116	15.9962	47.9886	16.0000	63.9886
120	15.9971	47.9914	16.0000	63.9914
124	15.9979	47.9936	16.0000	63.9936
128	15.9984	47.9952	16.0000	63.9952
132	15.9988	47.9964	16.0000	63.9964
136	15.9991	47.9973	16.0000	63.9973
140	15.9993	47.9980	16.0000	63.9980
144	15.9995	47.9985	16.0000	63.9985
148	15.9996	47.9989	16.0000	63.9989
152	15.9997	47.9991	16.0000	63.9991
156	15.9998	47.9994	16.0000	63.9994
160	15.9998	47.9995	16.0000	63.9995
164	15.9999	47.9996	16.0000	63.9996
168	15.9999	47.9997	16.0000	63.9997
172	15.9999	47.9998	16.0000	63.9998
176	15.9999	47.9998	16.0000	63.9998
180	16.0000	47.9999	16.0000	63.9999
184	16.0000	47.9999	16.0000	63.9999
188	16.0000	47.9999	16.0000	63.9999
192	16.0000	48.0000	16.0000	64.0000
196	16.0000	48.0000	16.0000	64.0000
200	16.0000	48.0000	16.0000	64.0000
204	16.0000	48.0000	16.0000	64.0000
208	16.0000	48.0000	16.0000	64.0000
212	16.0000	48.0000	16.0000	64.0000
216	16.0000	48.0000	16.0000	64.0000
220	16.0000	48.0000	16.0000	64.0000
224	16.0000	48.0000	16.0000	64.0000
228	16.0000	48.0000	16.0000	64.0000
232	16.0000	48.0000	16.0000	64.0000
236	16.0000	48.0000	16.0000	64.0000
240	16.0000	48.0000	16.0000	64.0000
244	16.0000	48.0000	0.0000	48.0000
248	12.0000	36.0000	0.0000	36.0000
252	9.0000	27.0000	0.0000	27.0000
256	6.7500	20.2500	0.0000	20.2500
260	5.0625	15.1875	0.0000	15.1875
264	3.7969	11.3906	0.0000	11.3906
268	2.8477	8.5430	0.0000	8.5430
272	2.1357	6.4072	0.0000	6.4072
276	1.6018	4.8054	0.0000	4.8054
280	1.2014	3.6041	0.0000	3.6041
284	0.9010	2.7030	0.0000	2.7030
288	0.6758	2.0273	0.0000	2.0273
292	0.5068	1.5205	0.0000	1.5205
296	0.3801	1.1403	0.0000	1.1403
300	0.2851	0.8553	0.0000	0.8553
304	0.2138	0.6414	0.0000	0.6414
308	0.1604	0.4811	0.0000	0.4811
312	0.1203	0.3608	0.0000	0.3608
316	0.0902	0.2706	0.0000	0.2706

320	0.0677	0.2030	0.0000	0.2030
324	0.0507	0.1522	0.0000	0.1522
328	0.0381	0.1142	0.0000	0.1142
332	0.0285	0.0856	0.0000	0.0856
336	0.0214	0.0642	0.0000	0.0642
340	0.0161	0.0482	0.0000	0.0482
344	0.0120	0.0361	0.0000	0.0361
348	0.0090	0.0271	0.0000	0.0271
352	0.0068	0.0203	0.0000	0.0203
356	0.0051	0.0152	0.0000	0.0152
360	0.0038	0.0114	0.0000	0.0114
364	0.0029	0.0086	0.0000	0.0086
368	0.0021	0.0064	0.0000	0.0064
372	0.0016	0.0048	0.0000	0.0048
376	0.0012	0.0036	0.0000	0.0036
380	0.0009	0.0027	0.0000	0.0027
384	0.0007	0.0020	0.0000	0.0020
388	0.0005	0.0015	0.0000	0.0015
392	0.0004	0.0011	0.0000	0.0011
396	0.0003	0.0009	0.0000	0.0009
400	0.0002	0.0006	0.0000	0.0006
404	0.0002	0.0005	0.0000	0.0005
408	0.0001	0.0004	0.0000	0.0004
412	0.0001	0.0003	0.0000	0.0003
416	0.0001	0.0002	0.0000	0.0002
420	0.0001	0.0002	0.0000	0.0002
424	0.0000	0.0001	0.0000	0.0001
428	0.0000	0.0001	0.0000	0.0001
432	0.0000	0.0001	0.0000	0.0001
436	0.0000	0.0000	0.0000	0.0000

Therefore, it will take 18 days (436 hours) for the patient to excrete all the medication.

If the patient must stop the medication after 10 days and wait until it is all excreted from his body, then the patient must wait 18 days (436 hours) until all the medication is excreted.

Size of the Box

There are 1,000,000 steel balls, each of which has a diameter of 1 mm. They are to be placed in a box. What is the size of the box, and can one person carry the box?
