

1. (1 pt) mathbioLibrary/setABioClabs/Lab121.I2.ht.wt.pg

Because of the accuracy of WebWork, you should use 5 or 6 significant figures on all problems.

Pediatricians monitor for normal growth of children by the annual measurement of height and weight. These are expected to increase annually, the growth curve paralleling a standardized curve. In the material introducing the idea of a derivative, there are data on juvenile heights from birth to age 18. Below is a table of both heights and weights for American girls in the 90th percentile.

age (years)	Height (cm)	Weight (kg)
0	52	3.8
0.25	62	6.4
0.5	70	8.4
0.75	75	9.8
1	79	10.7
1.5	86	12.3
2	91	13.6
3	99	15.9
4	107	18.2
5	114	21.4
6	121	25
7	128	28.2
8	133	33.2
9	141	37.3
10	147	43.2
11	153	50
12	159	55.5
13	165	61.4
14	168	65.9
15	170	69.1
16	171	70.9
17	172	71.8
18	172	71.8

a. We begin this problem by using allometric modeling to compare early childhood with later childhood. In particular, use the data from age 0 to 5 to find an allometric relationship between the height of a child and her weight. The best fitting power law model of the form

$$w = ah^k.$$

The best fit coefficients,  $a$  and  $k$ , found by Excel are

$$a = \underline{\hspace{2cm}}$$

$$k = \underline{\hspace{2cm}}.$$

Next use the data for height and weight to find an allometric model for girls between ages 4 and 18. If again,

$$w = ah^k.$$

The best fit coefficients,  $a$  and  $k$ , found by Excel are

$$a = \underline{\hspace{2cm}}$$

$$k = \underline{\hspace{2cm}}.$$

These models predict that a girl in the 90th percentile at age 2 with a height 91 cm should weigh

$$w = \underline{\hspace{2cm}} \text{ kg,}$$

which gives a percent error of (compared to the actual data, the best value)

$$\text{Percent error} = \underline{\hspace{2cm}}.$$

These models predict that a girl in the 90th percentile at age 9 with a height 141 cm should weigh

$$w = \underline{\hspace{2cm}} \text{ kg,}$$

which gives a percent error of

$$\text{Percent error} = \underline{\hspace{2cm}}.$$

These models predict that a girl in the 90th percentile at age 1 weighing 10.7 kg should measure

$$h = \underline{\hspace{2cm}} \text{ cm,}$$

which gives a percent error of (compared to the actual data, the best value)

$$\text{Percent error} = \underline{\hspace{2cm}}.$$

These models predict that a girl in the 90th percentile at age 12 weighing 55.5 kg should measure

$$h = \underline{\hspace{2cm}} \text{ cm,}$$

which gives a percent error of

$$\text{Percent error} = \underline{\hspace{2cm}}.$$

b. In your Lab Report, create the graphs for each of your allometric models over the given age ranges. Give a physiological explanation for the coefficient  $k$  that you obtained for the model spanning the ages 4-18. Why doesn't this value of  $k$  hold for the earlier years of child development? Give a brief discussion of how well your model fits the data.

c. We are soon beginning the lecture material for a derivative. In biology, one of the most common uses of the derivative is a measurement of growth. We want to examine the data in the Table above to determine the changes in growth rate at different ages.

The average rate of growth in height over a time period  $t \in [t_0, t_1]$  is easily computed by the formula:

$$g_{ht}(t) = \frac{h(t_1) - h(t_0)}{t_1 - t_0},$$

where we associate the growth rate,  $g_{ht}$ , with the earlier time  $t = t_0$ . Use the Table of data to compute the average rate of growth in height (in cm/yr) for each of the following age ranges:

Growth from age 0 to 3 months:

$$g_{ht} = \underline{\hspace{2cm}} \text{ cm/yr,}$$

Growth from age 0 to 6 months:

$$g_{ht} = \underline{\hspace{2cm}} \text{ cm/yr,}$$

Growth from age 0 to 1 year:

$$g_{ht} = \underline{\hspace{2cm}} \text{ cm/yr,}$$

Growth from age 1 to 2 years:

$$g_{ht} = \underline{\hspace{2cm}} \text{ cm/yr,}$$

Growth from age 0 to 5 years:

$$g_{ht} = \text{_____ cm/yr,}$$

Growth from age 2 to 5 years:

$$g_{ht} = \text{_____ cm/yr,}$$

Growth from age 5 to 7 years:

$$g_{ht} = \text{_____ cm/yr,}$$

Growth from age 10 to 12 years:

$$g_{ht} = \text{_____ cm/yr,}$$

Growth from age 12 to 15 years:

$$g_{ht} = \text{_____ cm/yr,}$$

Growth from age 15 to 18 years:

$$g_{ht} = \text{_____ cm/yr.}$$

d. In your Lab Report, create a graph of height versus age, then create another graph of rate of change in height versus age (much like the graphs seen in the text). Find each growth rate (change of height) from successive values of height in the Table. Associate the rate of change of height with the earlier age. What happens with the rate of change in height? Describe the graph for the rate of height gain over the early years (0-3), the ages 3-12, then adolescence (13-18).

e. Similarly, The average rate of growth in weight over a time period  $t \in [t_0, t_1]$  is easily computed by the formula:

$$g_{wt}(t_0) = \frac{w(t_1) - w(t_0)}{t_1 - t_0},$$

where we associate the growth rate,  $g_{wt}$ , with the earlier time  $t = t_0$ . Use the Table of data to compute the average rate of growth in weight (in kg/yr) for each of the following age ranges: Growth from age 0 to 3 months:

$$g_{wt} = \text{_____ kg/yr,}$$

Growth from age 0 to 6 months:

$$g_{wt} = \text{_____ kg/yr,}$$

Growth from age 0 to 1 year:

$$g_{wt} = \text{_____ kg/yr,}$$

Growth from age 1 to 2 years:

$$g_{wt} = \text{_____ kg/yr,}$$

Growth from age 0 to 5 years:

$$g_{wt} = \text{_____ kg/yr,}$$

Growth from age 2 to 5 years:

$$g_{wt} = \text{_____ kg/yr,}$$

Growth from age 5 to 7 years:

$$g_{wt} = \text{_____ kg/yr,}$$

Growth from age 10 to 12 years:

$$g_{wt} = \text{_____ kg/yr,}$$

Growth from age 12 to 15 years:

$$g_{wt} = \text{_____ kg/yr,}$$

Growth from age 15 to 18 years:

$$g_{wt} = \text{_____ kg/yr.}$$

f. In your Lab Report, create a graph of weight versus age, then create another graph of rate of change in weight versus age (much like the graphs seen in the notes). Find each growth rate (change of weight) from successive values of weight in the Table. Associate the rate of change of weight with the earlier age. What happens with the rate of change in weight? Describe the graph for the rate of weight gain over the early years (0-3), the ages 3-12, then adolescence (13-18) and compare these rate of changes to the ones you found for the rate of change in height in Part d.