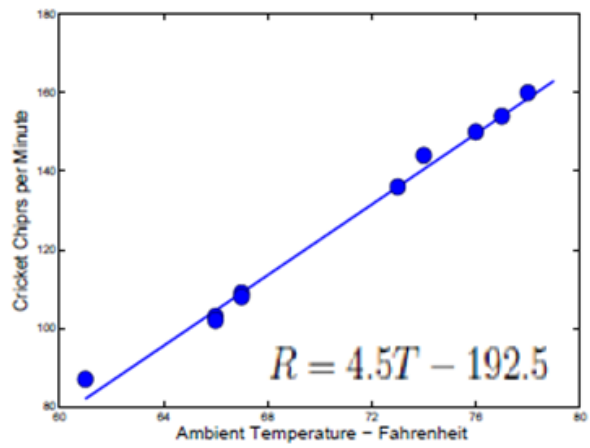
ALES 291/Math 120 **Assignment 1** Due: 1 pm Friday Jan 12

1. Cricket Chirping as a function of temperature

People have long noticed that crickets chirp more the warmer it is, and the phenomenon has been analyzed since at least 1897[1]. Shown below are some data, and a linear model derived from it, that relate the rate at which crickets chirp to the ambient temperature.

Temperature °F T	Chirps per Minute R
67	109
73	136
78	160
61	87
66	103
66	102
67	108
77	154
74	144
76	150



(The x-axis scale is from 60 to 80 in increments of 4.
The y-axis from 80 to 180 in increments of 20.)

a) Based on the model what frequency of chirps would you expect to hear at 70 degrees?

b) If you observe a chirp rate of 90 what would the model predict the temperature is?

c) What rate of chirps would the model predict at 100°F, and d) 40°F?

e) Are you confident in the predictions in c) and d)? Explain.

[1] A. E. Dolbear, The cricket as a thermometer, *American Naturalist* (1897) **31**, 970-971.
C. A. Bessey and E. A. Bessey, Further notes on thermometer crickets, *American Naturalist* (1898) **32**, 263-264.
H. A. Allard, The chirping rates of the snowy tree cricket (*Oecanthus niveus*) as affected by external conditions, *Canadian Entomologist* (1930) **52**, 131-142.

2. Seed production

The graph below[2] shows some data (the triangles) for seed production as a function of plant biomass, and a model derived from the data (the line).

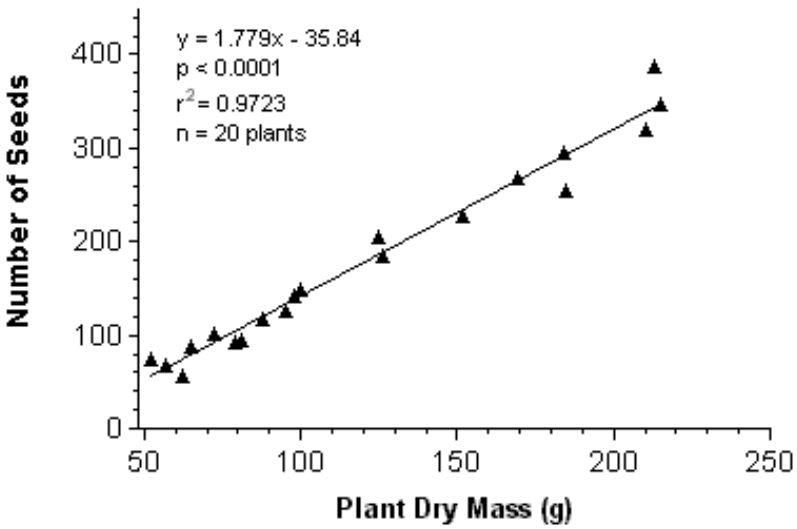


Figure 3. Seed production as a function of plant biomass in waterlilies (*Nuphar luteum*) harvested from Great Works Pond in Northern Maine in August, 2001.

Use the equation of the line to answer the following questions:

a) How many seeds would a 200 gram plant have? b) A 35 gram plant? c) A 300 gram plant?

d) How confident are you about each of the estimates in a), b) and c)?

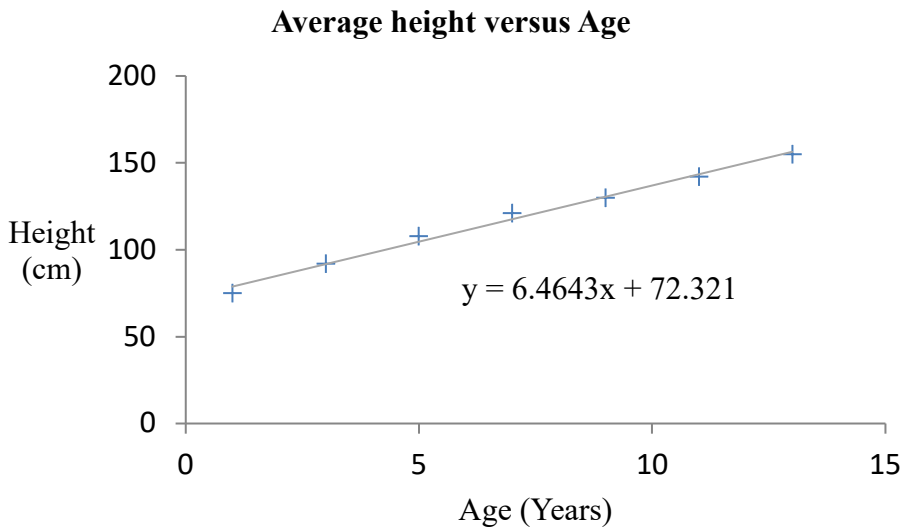
e) If you extend the line to the left which axis will it cross first?[3]

f) What is the interpretation of this intercept, i.e. what does it tell you about plants and their seeds?

[2] Retrieved from http://abacus.bates.edu/~ganderso/biology/resources/writing/HTWstats.html January 2014.
[3] Hint: Use the equation to calculate both the intercepts, and then examine their values.

3. Growing up

Organism growth is not generally linear. Instead organisms often grow in "spurts" that depend on their current environmental conditions, and on their genetics. Although few growth processes are linear for their entire cycle, many have approximately-linear portions. Here for example is some data and a linear model for the growth of juvenile humans[4].



a) How much does the typical child grow each year?

b) Based on the model what is the average height of an eight year old?

c) What height does the model predict for a newborn baby?[5] How accurate is this prediction? What is its percentage error?

d) What does the model predict your height should be? How accurate is this prediction? What is its percentage error?

[4] Data source: David N. Holvey, editor, *The Merck Manual of Diagnosis and Therapy* (1987) 15th ed., Merck Sharp & Dohme Research Laboratories, Rahway, NJ.
[5] Hint: You can ask Google for the actual "height" of a newborn baby.

4. Urchins grow too

Like humans, sea urchins grow linearly for a portion of their life. Suppose that a population of **white sea urchins** (*Lytechinus pictus*) has a mean diameter of **28 mm** at the beginning of June (June 1) and **33 mm** at the beginning of July (July 1).

a) *Assuming the growth is linear*, use the two given data points to derive an equation for sea urchin growth as a function of time[6].

b) Draw a graph of your model.

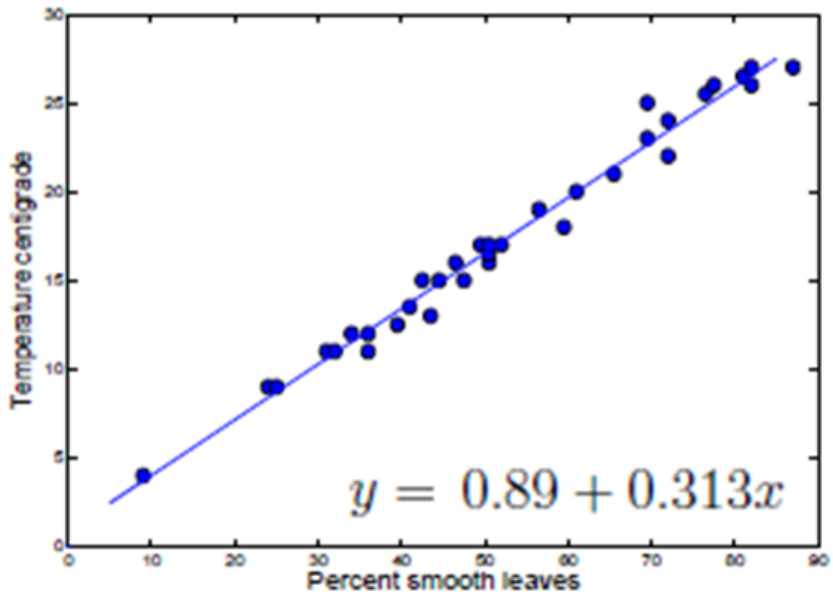
Use your model to estimate the mean diameter for the population of *Lytechinus pictus* on: c) July 10, d) June 20, e) August 1, and f) June 2.

g) Rank your estimates in c)-f) according to your confidence in their accuracy.

[6] Hint: This is similar to when we derived the Fahrenheit to Celsius conversion formula in class.

5. Leaf shape as a function of climate

Jack A. Wolfe noticed that the distribution of the shapes of trees' leaves varied with climate[7]: in warm climates more tree species have leaves with smooth edges, while in cold climates more have ragged, or incised, edges. Here's some of the data he collected based on 33 forests in eastern Asia, and a linear model of that data.



a) What percent of tree species in Whitehorse does the model predict will be smooth leaved?[8]

Wolfe made an interesting application of this model to estimate ambient temperatures over the last 65 million years. He analyzed numerous leaf fossils collected in Western North America from Alaska to Mississippi, and calculated the percentage of smooth leaf specimens at times from 50 million to 6 million years ago.

[7] Jack A. Wolfe, A paleobotanical interpretation of tertiary climates in northern hemisphere, *American Scientist* 66 (1979), 694-703

[8] Remember: Google is your friend and can lead you to a value for the average annual temperature here in Whitehorse.

Here's some of his data:

Age in Millions of years	% Smooth leaves	Estimated Temperature
50	57	
48	50	
48	51	
44	70	
44	74	
40	40	
40	44	
35	66	
35	68	
33	55	
31	24	
31	32	
26	32	

Age in Millions of years	% Smooth leaves	Estimated Temperature
26	40	
26	42	
21	24	
21	28	
21	32	
16	31	
16	34	
16	38	
10	28	
10	30	
10	32	
6	34	
6	38	

b) Use the model above to estimate the temperature for each sample and enter these into the table.

c) Create a graph showing these temperatures over time.

d) Has the variation of temperature been linear with time?

e) What assumptions are being made about the model and the data in this analysis?