Liam Fruzyna

1. Refer to section 2.3 for the fishing derby. Consider the model W proportional to l*l*g. In detail, interpret the model and explain how it differs from the other models presented in this section. Under what circumstances would the models coincide?

$W \propto l * l * g$

A sport fishing club wishes to encourage its members to catch and release but they also want to track the total weight of fish caught by members for awards. A scale is inconvenient so the weight should be approximated by the length of the fish.

Many factors can be considered. Different species have different shapes and average weight densities plus gender and season can play a role in weight.

Initially consider a single species of fish (bass) and assume that the average weight density is constant. Also, neglect gender and season.

Assuming all bass are geometrically similar we can calculate volume from a single dimension of the fish, then use that to calculate weight. So,

$W \propto V \propto l^3$

But, not all fish are geometrically similar so we can replace l^2 with the girth of the fish or the cross-sectional area.

$V \propto lg^2$

from where we can derive the model

$W = klg^2$

Other models don't go into the detail of breaking down the length dimension into anything more specific, but they do use a single length dimension to represent the weight. In this case length cubed becomes length times the cross-sectional area of the fish. This is to better account for different shapes of fish because they can be slimmer or thicker even when maintaining length.

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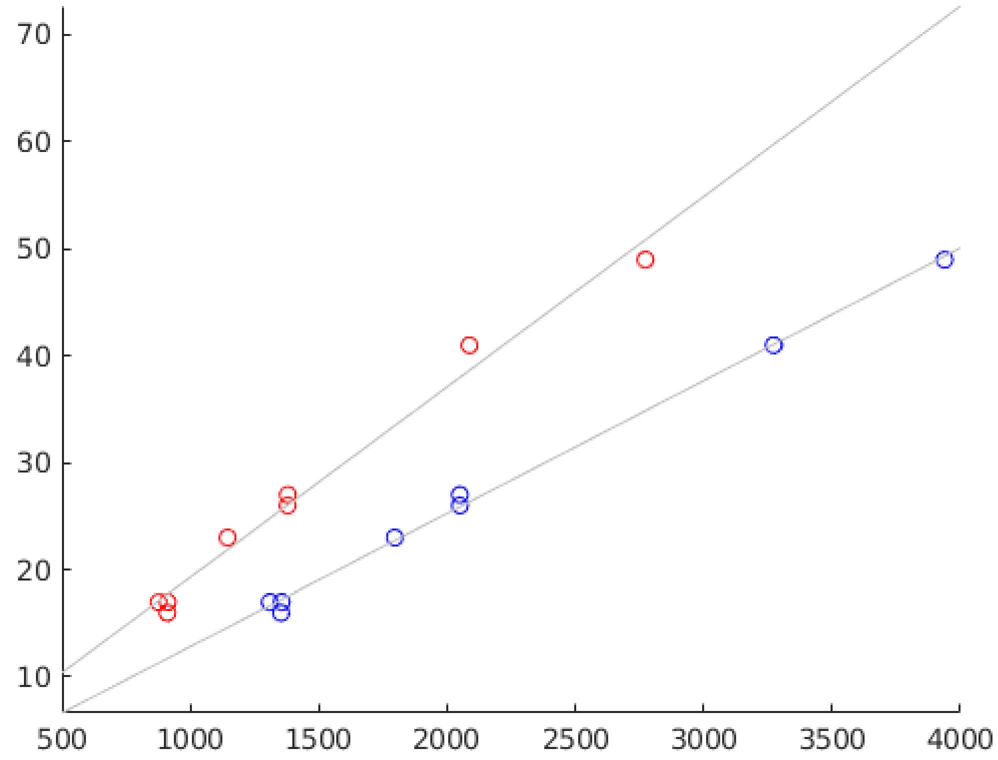
2. Plot W versus l*l*g to ascertain the appropriateness of this model. Comment on the result compared to the model W proportional to l*g*g presented in the text.

Note: the red line is the existing l*g*g model and the blue line is the new l*l*g model.



Both models appear very linear, because of this the slope shouldn't matter because the k value of the model will adjust it accordingly. However, the new model appears to be an improvement because the data is fitted tighter to the line than in the existing model.

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3. Consider determining the proportionality constant, k, for the model W = k*(l*l*g). Derive the equation for the least squares estimate of k using the technique presented in section 3.3 page 122.

$$y = kl^2g = k(l^2g)^1$$

$$k = \frac{\Sigma x_i^n y_i}{\Sigma x_i^{2n}}, n = 1$$

$$k = \frac{\Sigma x_i y_i}{\Sigma x_i^2}$$

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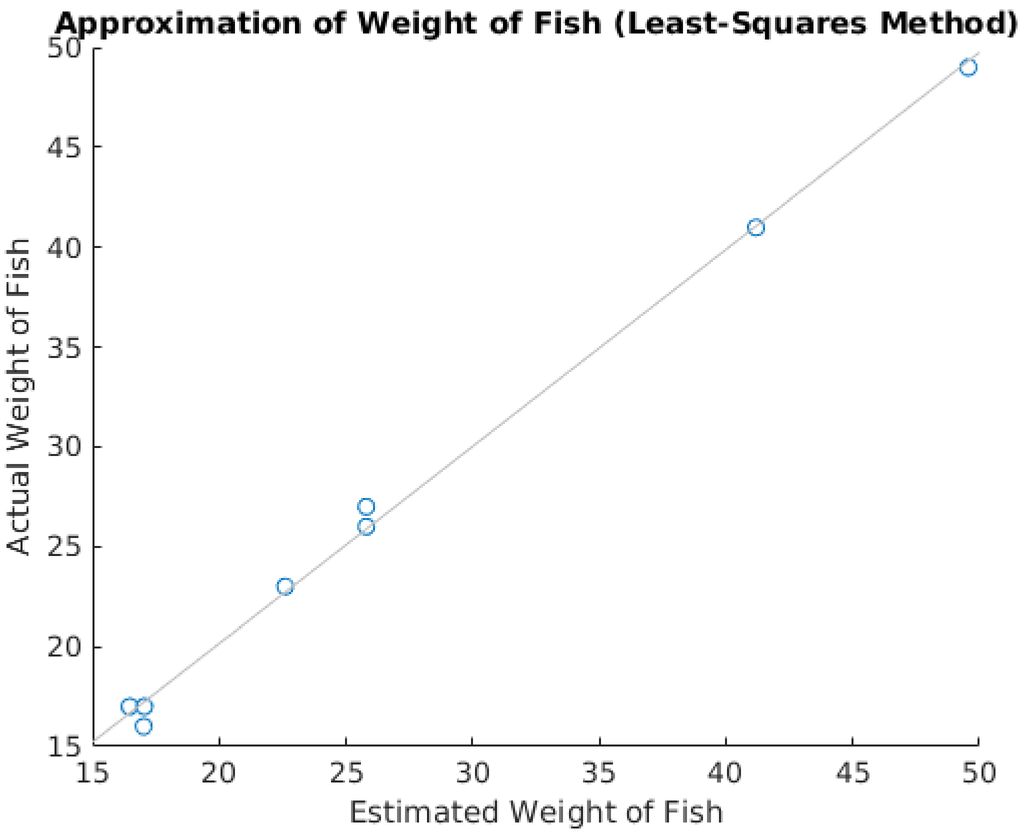
4. Code up the expression you derived in 3. above, in any environment you choose, and determine the least-squares estimate of k for the data presented for the derby on the bottom of page 86. Plot the data and the resulting model fit. Label the graph and the axes. Submit code and graph.

```
% Dermine the least-squares estimate of k and plot

lengths = [14.5 12.5 17.25 14.5 12.625 17.75 14.125 12.615];
girths  = [9.75 8.375 11.0 9.75 8.5 12.5 9.0 8.5];
weights = [27 17 41 26 17 49 23 16];

x = lengths.^2 .* girths;
y = weights;

xy = x .* weights;
x2 = x.^2;

a = sum(xy) / sum(x2)
estW = a .* x;

scatter(estW, weights);
title('Approximation of Weight of Fish (Least-Squares Method)')
xlabel('Estimated Weight of Fish')
ylabel('Actual Weight of Fish')
lsline
```



Approximation of Weight of Fish (Least-Squares Method)
Actual Weight of Fish
Estimated Weight of Fish
15
20
25
30
35
40
45
50

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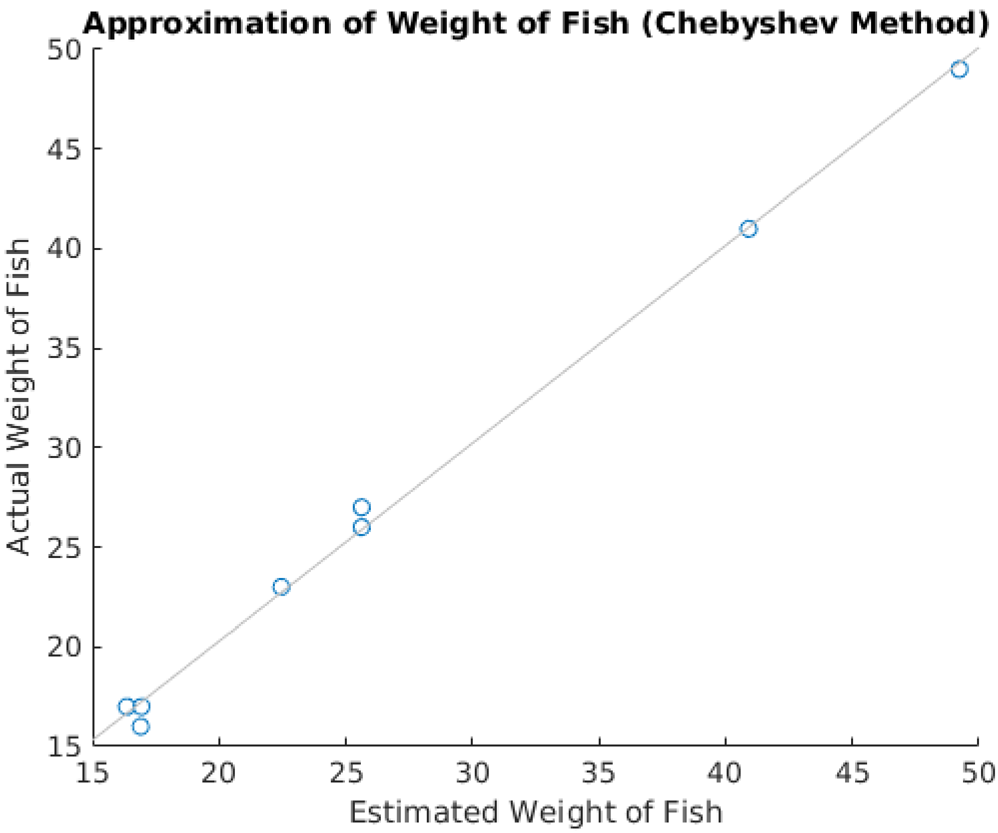
5. Now determine another value of k using Chebyshev's approximation criterion as presented in section 3.2 and 7.2. Plot the data and the resulting model fit. Submit code and graph.

```
% Dermine the Chebyshev estimate of k and plot

lengths = [14.5 12.5 17.25 14.5 12.625 17.75 14.125 12.615];
girths  = [9.75 8.375 11.0 9.75 8.5 12.5 9.0 8.5];
weights = [27 17 41 26 17 49 23 16];

x = lengths.^2 .* girths;
y = weights;

a = 0.01;
b = 0.02;
k = 0.015;
for i = 1:100
    adeltas = abs((a .* x) - weights);
    bdeltas = abs((b .* x) - weights);
    if max(adeltas) < max(bdeltas)
        b = k;
    else
        a = k;
    end
    k = a + (b - a)/2;
end

k

estW = k .* x;

scatter(estW, weights);
title('Approximation of Weight of Fish (Chebyshev Method)')
xlabel('Estimated Weight of Fish')
ylabel('Actual Weight of Fish')
lsline
```


Approximation of Weight of Fish (Chebyshev Method)
Actual Weight of Fish
Estimated Weight of Fish
15
20
25
30
35
40
45
50

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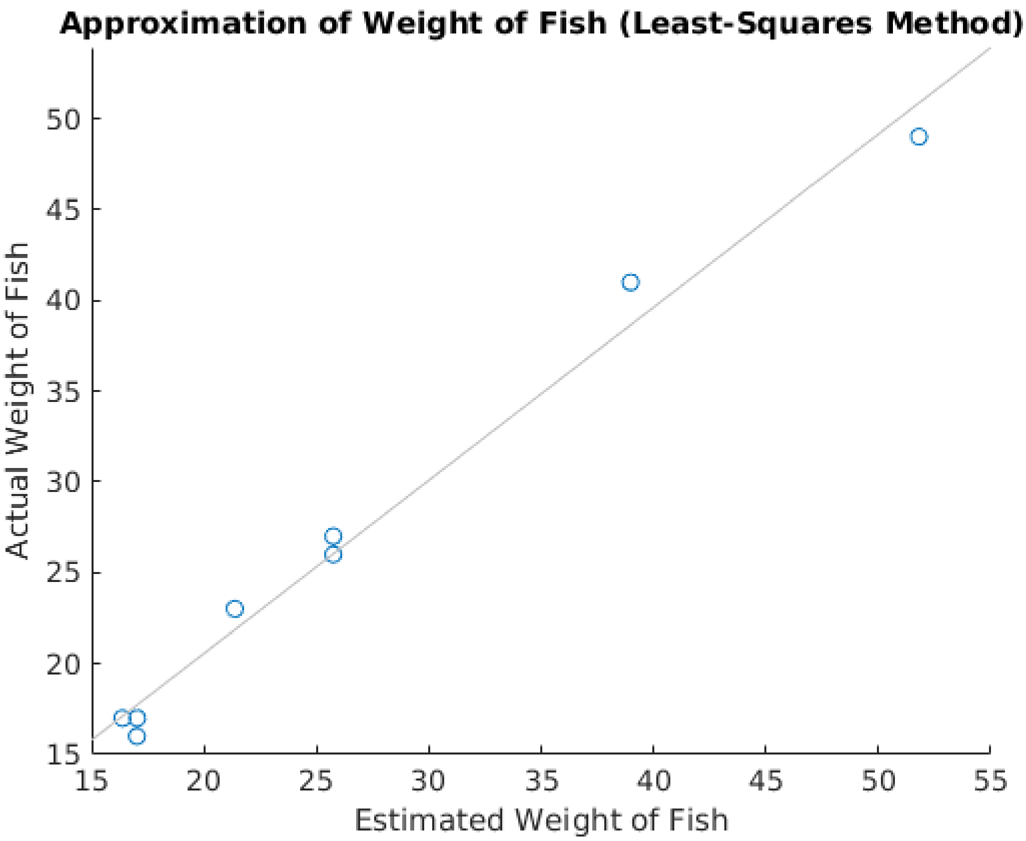
6. Repeat part 4. above using the model W = a*l*g*g.

```
% Dermine the least-squares estimate of k and plot

lengths = [14.5 12.5 17.25 14.5 12.625 17.75 14.125 12.615];
girths  = [9.75 8.375 11.0 9.75 8.5 12.5 9.0 8.5];
weights = [27 17 41 26 17 49 23 16];

x = lengths .* girths.^2;
y = weights;

xy = x .* weights;
x2 = x.^2;

a = sum(xy) / sum(x2)
estW = a .* x;

scatter(estW, weights);
title('Approximation of Weight of Fish (Least-Squares Method)')
xlabel('Estimated Weight of Fish')
ylabel('Actual Weight of Fish')
lsline
```


Approximation of Weight of Fish (Least-Squares Method)
Actual Weight of Fish
Estimated Weight of Fish
15
20
25
30
35
40
45
50
55

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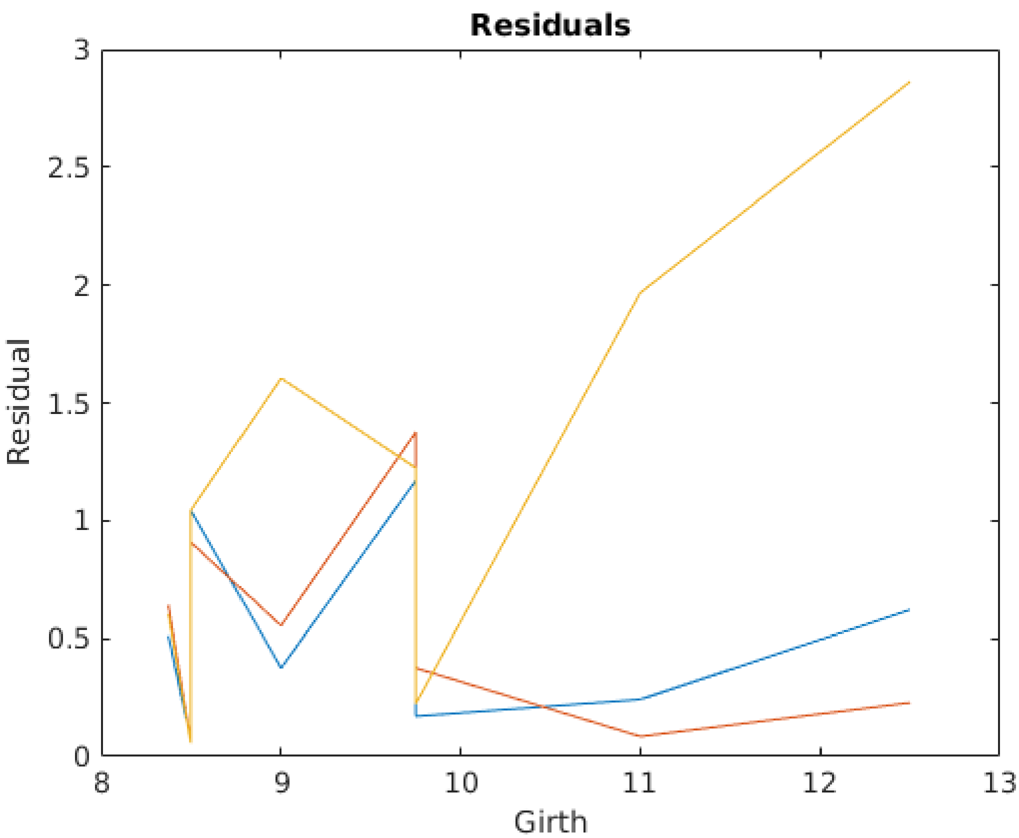
7. Choose the best model from amongst the following three: i) that obtained from part 4. above, ii) that obtained from part 5 above, and iii) that obtained from part 6 above.

Prepare a table similar to Table 3.6 in the book. Also plot the residuals as a function of l for each model. Also plot the residuals as a function of g for each model.

Model	$\Sigma[y_i - y(x_i)]^2$	$Max\|y_i - y(x_i)\|$
$W = 0.0126l^2g$	3.3426	1.1708
$W = 0.0125l^2g$	3.6433	1.3758
$W = 0.0187lg^2$	17.6548	2.8633



Based on all of this information discuss which model is the "best".

The first model, $W = 0.0126l^2g$, is definitely the best. The original model's residuals are not nearly as tight as in the l*l*g models. When looking at individual residuals in the l*l*g models, the two models trade blows on each girth but the Chebychev model's residuals in totality are still slightly larger.