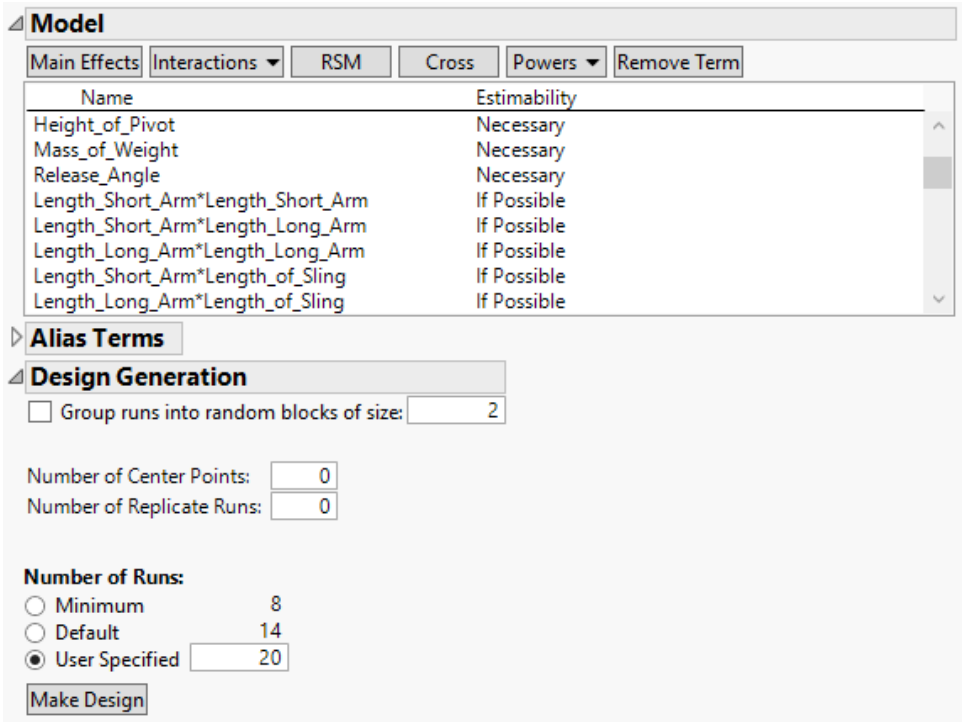
Kris Fargo
MATH 740 – Homework 5

## 1. Virtual Trebuchet

### Chosen Parameters:

| Factor | Value Low | Value High |
|---|---|---|
| Short Arm | 1 ft | 2 ft |
| Long Arm | 5 ft | 8 ft |
| Sling | 2 ft | 4 ft |
| Length of Weight | 1 ft | 2 ft |
| Height of Pivot | 3 ft | 5 ft |
| Mass | 250 lb | 500 lb |
| Release Angle | 30 deg | 45 deg |



## Alias Matrix:

| Alias Matrix | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Effect | Length_Sl | Length_Sl | Length_Sl | Length_Sl | Length_Sl | Length_Sl | Length_Lc | Length_Lc | Length_Lc | Length_Lc | Length_Lc | Length_of | Length_of | Length_of | Length_of | Length_of | Length_of | Length_of | Height_of | Height_of | Mass_of_V |
| Intercept | 0.194 | -0.16 | 0.154 | -0.2 | -0.12 | -0.14 | 0.162 | -0.03 | 0.046 | 0.204 | -0.03 | 0.171 | -0.17 | -0.16 | -0.18 | -0.05 | 0.189 | 0.027 | -0.14 | -0.05 | -0.15 |
| Length_Short_Arm | -0.04 | 0.034 | -0.04 | 0.038 | 0.034 | 0.034 | -4.00E-03 | 0.03 | -0.06 | -0.07 | -0.05 | -0.07 | 0.065 | 0.034 | 0.008 | -0.06 | -0.01 | -0.06 | 0.063 | 0.034 | 0.006 |
| Length_Long_Arm | 0.056 | -0.03 | 0.018 | -0.06 | 0.003 | -0.02 | 0.035 | -6.00E-04 | 0.005 | 0.058 | 0.089 | 0.037 | -0.04 | -0.03 | -0.04 | -0.08 | 0.056 | 0.001 | -0.02 | -5.00E-03 | -0.02 |
| Length_of_Sling | -0.01 | 0.034 | -0.01 | 0.067 | 0.035 | 0.063 | -0.03 | 0.059 | -0.06 | -0.01 | -0.02 | -0.04 | 0.036 | 0.034 | 0.038 | -0.03 | -0.06 | -0.06 | 0.005 | 0.063 | 0.066 |
| Length_of_Weight | 0.04 | -0.06 | 0.043 | -0.02 | -0.07 | -0.07 | 0.064 | -0.03 | -0.07 | 0.018 | 0.006 | 0.043 | -0.04 | -0.06 | -0.02 | 0.029 | 0.042 | 0.028 | -0.06 | 0.067 | -0.05 |
| Height_of_Pivot | -0.02 | 0.017 | -0.07 | 0.046 | 0.068 | 0.044 | -0.02 | -0.07 | -0.03 | -0.04 | -0.01 | -0.04 | 0.044 | 0.017 | 0.071 | -0.03 | -0.02 | 0.07 | 0.042 | 0.034 | 0.071 |
| Mass_of_Weight | -0.07 | 0.034 | -0.07 | 0.008 | 0.034 | 0.004 | -0.06 | 0.059 | -0.03 | -0.04 | -0.05 | -0.01 | 0.006 | 0.034 | 0.067 | -0.06 | -0.04 | -0.03 | 0.034 | 0.063 | 0.036 |
| Release_Angle | -0.06 | 0.035 | -0.02 | 0.058 | -3.00E-03 | 0.016 | -0.03 | 0.001 | -5.00E-03 | -0.06 | -0.09 | -0.04 | 0.037 | 0.035 | 0.039 | 0.078 | -0.06 | -6.00E-04 | 0.016 | 0.005 | 0.018 |
| Length_Short_Arm*Length_Short_Arm | -0.08 | 0.071 | -0.07 | 0.083 | 0.064 | 0.066 | -0.34 | 0.042 | 0.215 | 0.18 | 0.286 | 0.189 | -0.19 | 0.071 | 0.345 | 0.235 | -0.34 | 0.223 | -0.2 | 0.05 | 0.336 |
| Length_Short_Arm*Length_Long_Arm | 0.072 | -0.04 | 0.017 | 0.015 | 0.018 | 0.022 | 0.043 | -0.03 | -0.01 | 0.043 | 0.053 | 0.008 | 0.013 | -0.02 | -0.02 | 0.009 | 0.014 | 0.024 | -0.02 | -0.01 | 0.02 |
| Length_Long_Arm*Length_Long_Arm | -0.07 | 0.357 | 0.031 | -0.27 | 0.256 | 0.305 | -0.02 | -0.03 | 0.026 | -0.07 | -0.09 | -0.36 | -0.32 | -0.32 | 0.019 | -0.11 | 0.273 | -0.31 | -0.03 | 0.314 | 0.306 |
| Length_Short_Arm*Length_of_Sling | -0.04 | 0.063 | 0.011 | -0.01 | 0.015 | 0.039 | -0.04 | 0.033 | 0.019 | -0.01 | -0.01 | -0.03 | -0.01 | 0.02 | -0.01 | -0.02 | -0.02 | -0.05 | 0.017 | 0.002 | 0.01 |
| Length_Long_Arm*Length_of_Sling | 0.043 | -0.04 | 0.016 | 0.017 | -0.01 | -0.01 | 0.073 | -0.06 | -0.02 | -0.02 | 0.012 | -0.02 | 0.018 | -0.04 | -0.02 | 0.021 | 0.042 | 0.028 | -0.01 | -0.01 | -0.02 |
| Length_of_Sling*Length_of_Sling | -0.35 | 0.072 | -0.34 | -0.18 | 0.058 | -0.2 | -0.07 | -0.22 | 0.212 | -0.35 | 0.013 | -0.08 | 0.076 | 0.072 | 0.081 | -0.02 | 0.183 | 0.221 | 0.332 | -0.21 | -0.2 |
| Length_Short_Arm*Length_of_Weight | 0.017 | 0.011 | 0.076 | 0.019 | -0.05 | 0.013 | 0.016 | -0.01 | 0.019 | 0.017 | 0.005 | -0.01 | -0.01 | -0.01 | -0.05 | 0.066 | -0.02 | -0.02 | -0.04 | -0.02 | -0.02 |
| Length_Long_Arm*Length_of_Weight | -0.03 | 0.033 | -0.01 | 0.014 | 0.01 | 0.021 | -0.06 | 0.097 | -0.01 | 0.012 | -0.04 | 0.009 | 0.013 | 0.054 | 0.008 | -0.02 | -0.06 | -0.07 | 0.016 | 0.012 | 0.011 |
| Length_of_Sling*Length_of_Weight | 0.008 | -0.03 | -0.01 | -0.02 | -0.02 | -0.04 | -0.02 | 0.009 | 0.024 | 0.04 | 0.013 | 0.067 | -0.02 | 0.008 | 0.016 | 0.022 | -0.01 | 0.044 | -0.02 | -0.01 | -0.01 |
| Length_of_Weight*Length_of_Weight | -0.05 | -0.22 | -0.06 | 0.324 | -0.21 | -0.21 | 0.22 | 0.078 | -0.14 | -0.32 | -0.22 | -0.05 | 0.054 | -0.22 | 0.327 | -0.1 | -0.05 | -0.08 | -0.22 | 0.136 | 0.061 |
| Length_Short_Arm*Height_of_Pivot | 0.015 | -0.01 | 0.019 | 0.073 | -0.02 | 0.017 | 0.017 | 0.014 | -0.06 | -0.02 | -0.02 | -0.02 | 0.04 | 0.009 | 0.014 | 0.02 | -0.04 | -0.02 | -0.02 | 0.031 | 0.017 |
| Length_Long_Arm*Height_of_Pivot | -0.01 | 0.019 | 0.019 | -0.06 | -0.01 | -0.01 | -0.02 | -0.01 | 0.101 | 0.032 | 0.046 | 0.024 | -0.05 | -2.00E-03 | -0.03 | 0.026 | 0.014 | 0.012 | -0.01 | -0.07 | -0.02 |
| Length_of_Sling*Height_of_Pivot | 0.013 | -0.01 | -0.01 | 0.04 | 0.015 | 0.019 | 0.018 | 0.013 | -0.05 | -0.02 | -0.01 | -0.02 | 0.067 | 0.035 | -0.02 | -0.02 | -0.01 | -0.02 | 0.041 | -0.01 | -0.01 |
| Length_of_Weight*Height_of_Pivot | 0.009 | -0.02 | 0.066 | 0.02 | -0.08 | -0.03 | 0.021 | -0.02 | 0.026 | 0.01 | -4.00E-03 | 0.022 | -0.02 | -0.02 | -0.02 | 0.122 | -0.02 | 0.024 | -0.06 | -0.03 | -0.04 |
| Height_of_Pivot*Height_of_Pivot | -0.3 | 0.307 | 0.23 | 0.038 | -0.23 | 0.042 | -0.31 | 0.111 | -0.06 | -0.03 | -0.21 | -0.04 | 0.038 | 0.307 | -0.23 | -0.07 | -0.31 | -0.11 | 0.039 | 0.063 | -0.23 |
| Length_Short_Arm*Mass_of_Weight | 0.018 | 0.015 | -0.05 | -0.02 | 0.08 | 0.048 | -0.01 | 0.01 | -0.01 | 0.017 | 0.036 | -0.02 | 0.015 | 0.015 | 0.016 | -0.08 | 0.017 | -0.01 | 0.047 | 0.011 | 0.049 |
| Length_Long_Arm*Mass_of_Weight | 0.043 | -0.01 | 0.017 | -0.02 | 0.017 | 0.02 | -0.02 | 0.012 | 0.032 | 0.074 | 0.054 | 0.04 | -0.02 | 0.012 | -0.01 | 0.01 | -0.02 | 0.014 | -0.02 | -0.03 | 0.02 |
| Length_of_Sling*Mass_of_Weight | -0.02 | 0.02 | -0.01 | 0.009 | 0.015 | 0.017 | -0.04 | 0.054 | -2.00E-03 | 0.012 | -0.01 | 0.008 | 0.035 | 0.063 | -0.01 | -0.02 | -0.04 | -0.03 | 0.039 | -0.02 | -0.01 |
| Length_of_Weight*Mass_of_Weight | 0.014 | -0.02 | -0.02 | -0.04 | 0.017 | -0.01 | 0.042 | -0.06 | 0.014 | -0.02 | 0.021 | -0.01 | -0.01 | -0.04 | -0.01 | -0.02 | 0.071 | 0.029 | 0.021 | -0.02 | -0.02 |
| Height_of_Pivot*Mass_of_Weight | -0.02 | 0.017 | -0.04 | -0.02 | 0.047 | 0.017 | -0.01 | 0.016 | -0.01 | -0.02 | -4.00E-03 | -0.02 | 0.041 | 0.039 | -0.01 | -0.06 | 0.021 | -0.02 | 0.074 | -0.02 | -0.01 |
| Mass_of_Weight*Mass_of_Weight | 0.184 | 0.071 | 0.192 | 0.348 | 0.064 | 0.331 | 0.194 | -0.22 | -0.05 | -0.09 | 0.286 | -0.34 | 0.341 | 0.071 | -0.19 | 0.235 | -0.08 | -0.04 | 0.069 | -0.21 | 0.071 |
| Length_Short_Arm*Release_Angle | 0.022 | 0.039 | 0.013 | 0.017 | 0.048 | 0.075 | -0.01 | 0.021 | -0.01 | 0.02 | 0.028 | -0.04 | 0.019 | 0.017 | -0.01 | -0.03 | -0.01 | -0.05 | 0.017 | 0.007 | 0.045 |
| Length_Long_Arm*Release_Angle | 0.053 | -0.01 | 0.005 | -0.02 | 0.036 | 0.028 | 0.012 | -0.04 | 0.046 | 0.054 | 0.098 | 0.013 | -0.01 | -0.01 | -0.01 | -4.00E-03 | 0.021 | 0.045 | -4.00E-03 | -0.05 | 0.027 |
| Length_of_Sling*Release_Angle | -0.02 | -0.01 | -0.05 | 0.014 | 0.016 | -0.01 | -0.02 | 0.008 | -0.03 | -0.01 | -0.01 | 0.016 | -0.02 | -0.01 | 0.076 | -0.02 | -0.01 | 0.023 | -0.01 | 0.063 | 0.046 |
| Length_of_Weight*Release_Angle | 0.024 | -0.05 | -0.02 | -0.02 | -0.01 | -0.05 | 0.028 | -0.07 | 0.012 | 0.014 | 0.045 | 0.044 | -0.02 | -0.03 | 0.023 | 0.024 | 0.029 | 0.097 | -0.02 | -0.01 | -0.01 |
| Height_of_Pivot*Release_Angle | -0.01 | 0.002 | -0.02 | 0.031 | 0.011 | 0.007 | -0.01 | 0.012 | -0.07 | -0.03 | -0.05 | -0.01 | -0.01 | -0.02 | 0.063 | -0.03 | -0.02 | -0.01 | -0.02 | 0.101 | 0.05 |
| Mass_of_Weight*Release_Angle | 0.02 | 0.01 | -0.02 | 0.017 | 0.049 | 0.045 | -0.02 | 0.011 | -0.02 | 0.02 | 0.027 | -0.01 | -0.01 | -0.01 | 0.046 | -0.04 | -0.02 | -0.01 | -0.01 | 0.05 | 0.076 |
| Release_Angle*Release_Angle | 0.27 | -0.32 | -0.31 | 0.068 | 0.256 | -0.04 | -0.02 | 0.312 | -0.31 | 0.269 | -0.09 | 0.322 | 0.358 | 0.357 | 0.019 | -0.11 | -0.07 | 0.028 | 0.308 | -0.03 | -0.03 |

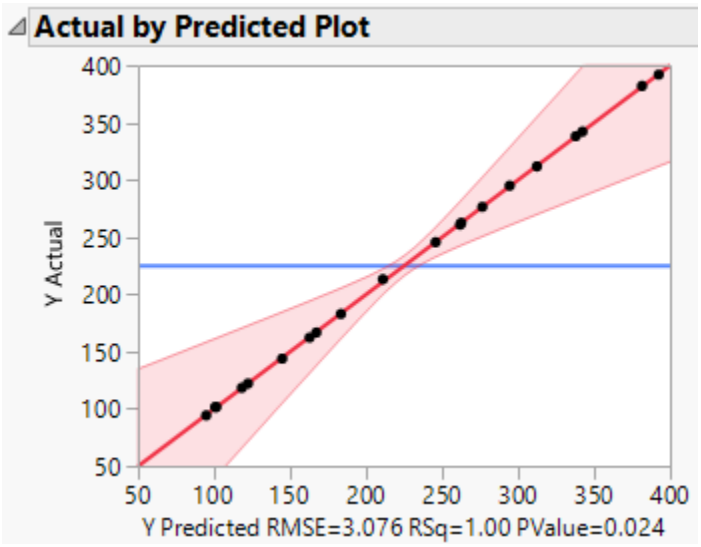
According to the alias matrix, this is not an orthogonal design. Many of the factors are partially aliased with each other.

## Acquired Data:

| | Length_Short_Arm | Length_Long_Arm | Length_of_Sling | Length_of_Weight | Height_of_Pivot | Mass_of_Weight | Release_Angle | Y |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 6.5 | 3 | 2 | 5 | 250 | 37.5 | 143.901 |
| 2 | 1.5 | 5 | 2 | 2 | 4 | 500 | 37.5 | 101.698 |
| 3 | 2 | 6.5 | 2 | 1 | 4 | 375 | 30 | 94.325 |
| 4 | 1.5 | 6.5 | 2 | 1.5 | 3 | 250 | 45 | 118.435 |
| 5 | 1 | 8 | 2 | 1.5 | 5 | 375 | 37.5 | 122.141 |
| 6 | 1.5 | 6.5 | 3 | 1.5 | 4 | 500 | 37.5 | 260.965 |
| 7 | 1 | 5 | 3 | 1.5 | 4 | 250 | 30 | 245.602 |
| 8 | 1.5 | 6.5 | 3 | 1 | 5 | 375 | 37.5 | 166.712 |
| 9 | 1 | 6.5 | 3 | 1 | 3 | 500 | 37.5 | 338.163 |
| 10 | 1.5 | 6.5 | 4 | 1.5 | 5 | 500 | 30 | 382.072 |
| 11 | 2 | 5 | 4 | 1 | 5 | 500 | 45 | 276.453 |
| 12 | 2 | 8 | 3 | 1.5 | 4 | 500 | 45 | 182.959 |
| 13 | 1.5 | 5 | 3 | 1 | 4 | 375 | 45 | 162.269 |
| 14 | 1 | 6.5 | 4 | 2 | 4 | 375 | 45 | 342.185 |
| 15 | 1.5 | 5 | 3 | 1.5 | 5 | 375 | 45 | 101.569 |
| 16 | 2 | 5 | 4 | 1.5 | 3 | 375 | 37.5 | 311.85 |
| 17 | 2 | 6.5 | 3 | 1.5 | 4 | 375 | 37.5 | 213.229 |
| 18 | 1.5 | 8 | 4 | 1 | 4 | 250 | 37.5 | 294.964 |
| 19 | 1.5 | 6.5 | 4 | 1.5 | 4 | 375 | 37.5 | 391.958 |
| 20 | 1.5 | 8 | 3 | 2 | 3 | 375 | 30 | 262.576 |

## 2. JMP Analysis

### BIC:




**Press**

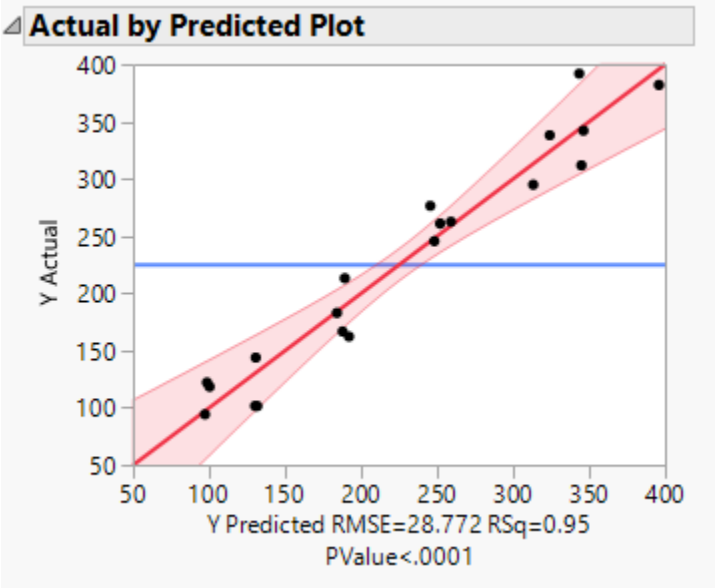
| Press | Press RMSE |
|---|---|
| 171163.69367 | 92.5104572 |

**Parameter Estimates**

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 236.69784 | 3.111439 | 76.07 | 0.0084* |
| Length_Short_Arm(1,2) | -39.10438 | 1.051502 | -37.19 | 0.0171* |
| Length_Long_Arm(5,8) | 10.576281 | 1.235912 | 8.56 | 0.0741 |
| Length_of_Sling(2,4) | 111.7429 | 1.085524 | 102.94 | 0.0062* |
| Length_of_Weight(1,2) | 0.6753925 | 1.186076 | 0.57 | 0.6705 |
| Height_of_Pivot(3,5) | -33.00378 | 1.235912 | -26.70 | 0.0238* |
| Mass_of_Weight(250,500) | 25.139684 | 1.082051 | 23.23 | 0.0274* |
| Release_Angle(30,45) | -27.76453 | 1.235912 | -22.46 | 0.0283* |
| Length_Short_Arm*Length_Short_Arm | 13.414558 | 3.029425 | 4.43 | 0.1414 |
| Length_Short_Arm*Length_Long_Arm | 61.192373 | 8.767293 | 6.98 | 0.0906 |
| Length_Long_Arm*Length_Long_Arm | -34.88383 | 3.421182 | -10.20 | 0.0622 |
| Length_Short_Arm*Length_of_Sling | 75.625841 | 5.163396 | 14.65 | 0.0434* |
| Length_of_Sling*Length_of_Sling | 44.046062 | 4.597785 | 9.58 | 0.0662 |
| Length_Short_Arm*Height_of_Pivot | 2.1421625 | 2.647978 | 0.81 | 0.5670 |
| Length_of_Weight*Height_of_Pivot | -18.51495 | 5.511423 | -3.36 | 0.1842 |
| Height_of_Pivot*Height_of_Pivot | -54.29281 | 4.446843 | -12.21 | 0.0520 |
| Length_Short_Arm*Mass_of_Weight | -61.86282 | 10.25897 | -6.03 | 0.1046 |
| Length_of_Sling*Mass_of_Weight | 47.938894 | 4.424632 | 10.83 | 0.0586 |
| Height_of_Pivot*Release_Angle | 24.54631 | 3.610286 | 6.80 | 0.0930 |

The BIC model seems to indicate overfitting of the model. This large model might begin to become subject to effect sparsity. This fit could include partial confounding and would likely benefit from increased runs or a different model.

**AICc:**




**Press**

| Press | Press RMSE |
|---|---|
| 27320.728614 | 36.9599301 |

**Parameter Estimates**

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 221.72405 | 6.681922 | 33.18 | <.0001* |
| Length_Short_Arm(1,2) | -32.51104 | 9.371302 | -3.47 | 0.0046* |
| Length_of_Sling(2,4) | 121.73974 | 9.371302 | 12.99 | <.0001* |
| Height_of_Pivot(3,5) | -33.93349 | 9.371302 | -3.62 | 0.0035* |
| Mass_of_Weight(250,500) | 30.242514 | 9.371302 | 3.23 | 0.0073* |
| Release_Angle(30,45) | -29.77004 | 9.371302 | -3.18 | 0.0080* |
| Length_Short_Arm*Mass_of_Weight | -5.637831 | 13.48743 | -0.42 | 0.6833 |
| Height_of_Pivot*Release_Angle | -26.35258 | 13.48743 | -1.95 | 0.0744 |

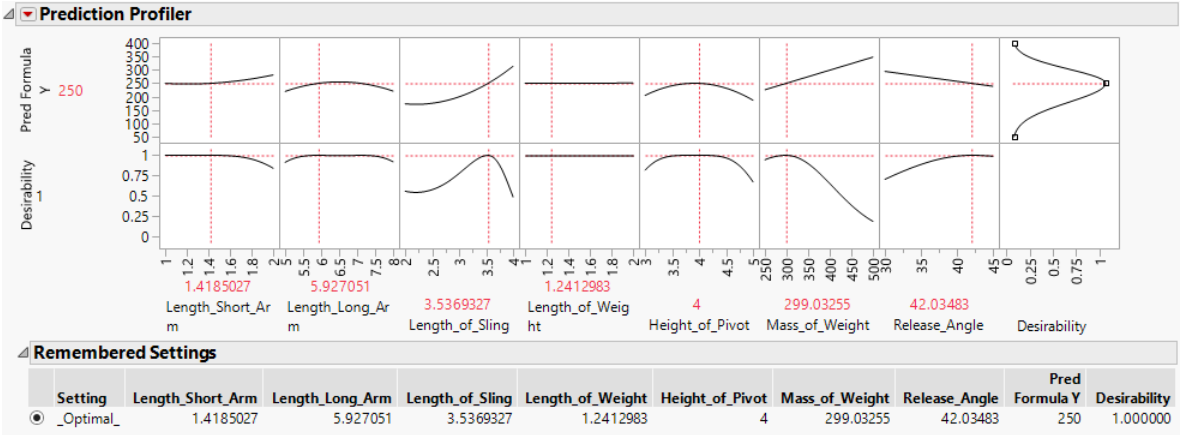
The AICc model does not indicate over-fitting, but with a possibility of lack of fit. The Std Error in the parameter estimates is of note in comparison to the other model, yet the press is much lower.

According to the prediction error sum of squares (Press), the AICc model prediction is more accurate than BIC and I would expect that it would predict the factor values for a given target distance better.

## 3. Profiler

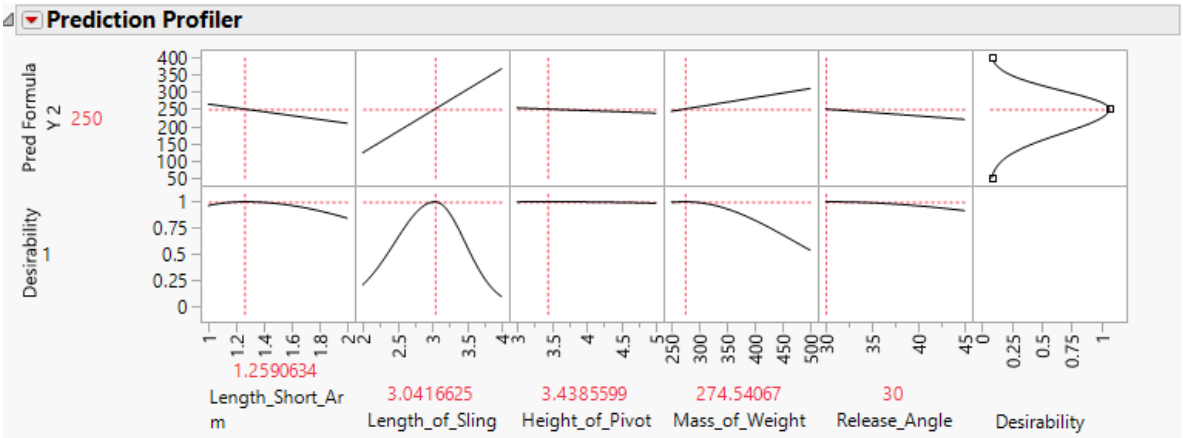
### a. Prediction Profiler and Desirability

**BIC:**




| Setting | Length_Short_Arm | Length_Long_Arm | Length_of_Sling | Length_of_Weight | Height_of_Pivot | Mass_of_Weight | Release_Angle | Pred Formula Y | Desirability |
|---|---|---|---|---|---|---|---|---|---|
| _Optimal_ | 1.4185027 | 5.927051 | 3.5369327 | 1.2412983 | 4 | 299.03255 | 42.03483 | 250 | 1.000000 |

**AICc:**




| Setting | Length_Short_Arm | Length_of_Sling | Height_of_Pivot | Mass_of_Weight | Release_Angle | Pred Formula Y 2 | Desirability |
|---|---|---|---|---|---|---|---|
| _Optimal_ | 1.2590634 | 3.0416625 | 3.4385599 | 274.54067 | 30 | 249.99999 | 1.000000 |

**b. Testing (250 ft target)**

BIC:

| **Observed Distance** | 262 ft |
|---|---|
| **Error** | 12 ft |

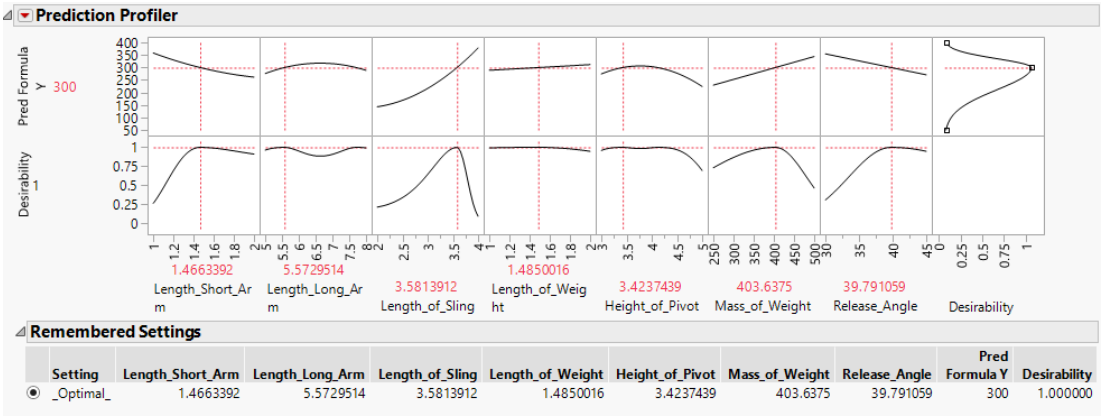
AICc:

| **Observed Distance** | 246.98 ft |
|---|---|
| **Error** | 3.02 ft |

From the observed distances and their error from 250 ft, the AICc model appears to be most accurate, which correlates with the press values observed earlier.

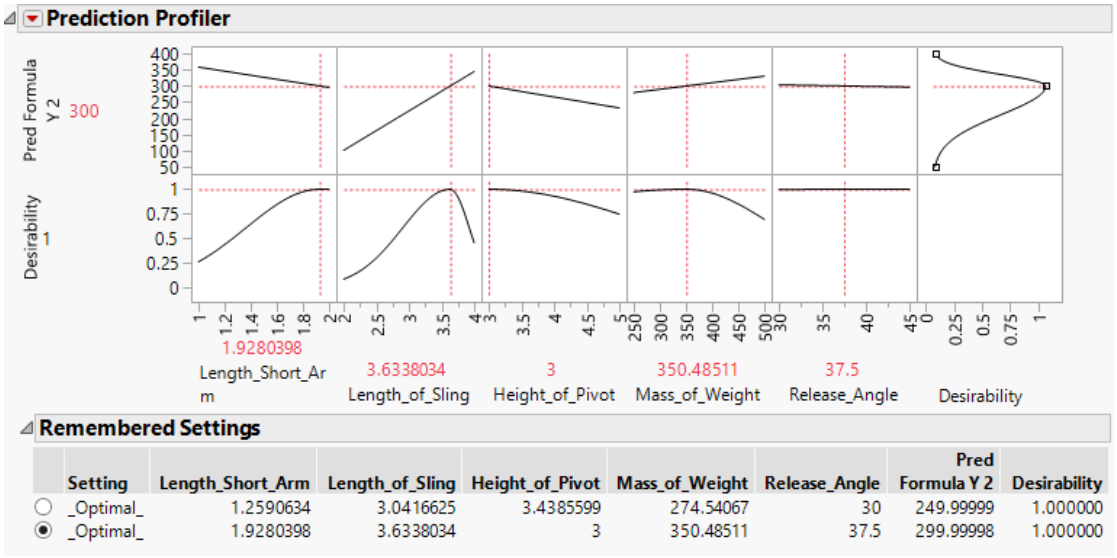
## c. Testing (300 ft target)

BIC:




| **Observed Distance** | 369.96 ft |
|---|---|
| **Error** | 69.96 ft |

AICc:




| **Observed Distance** | 306.92 ft |
|---|---|
| **Error** | 6.92 ft |

Again, the BIC model is less accurate in this prediction, and matches observations made for the 250 ft target and the press values in the model.