Teaching Basic Experimental Design with Catapults and other Hands-On Activities

Mark G. Haug, PhD, JD, University of Kansas School of Business
USCOTS 2007 Breakout Session

I. Intellectual Property issues on Catapults (and other devices)

A. Patents

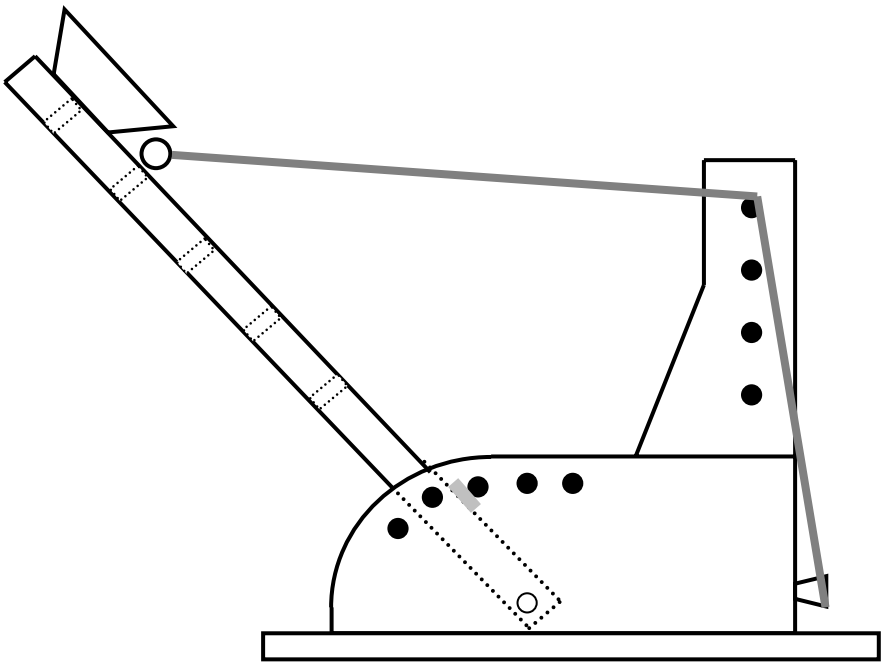
1. Issues

B. Trademarks

1. STATAPULT
   a) Registered (®) 2006 to Air Academy Press and Associates, LLC

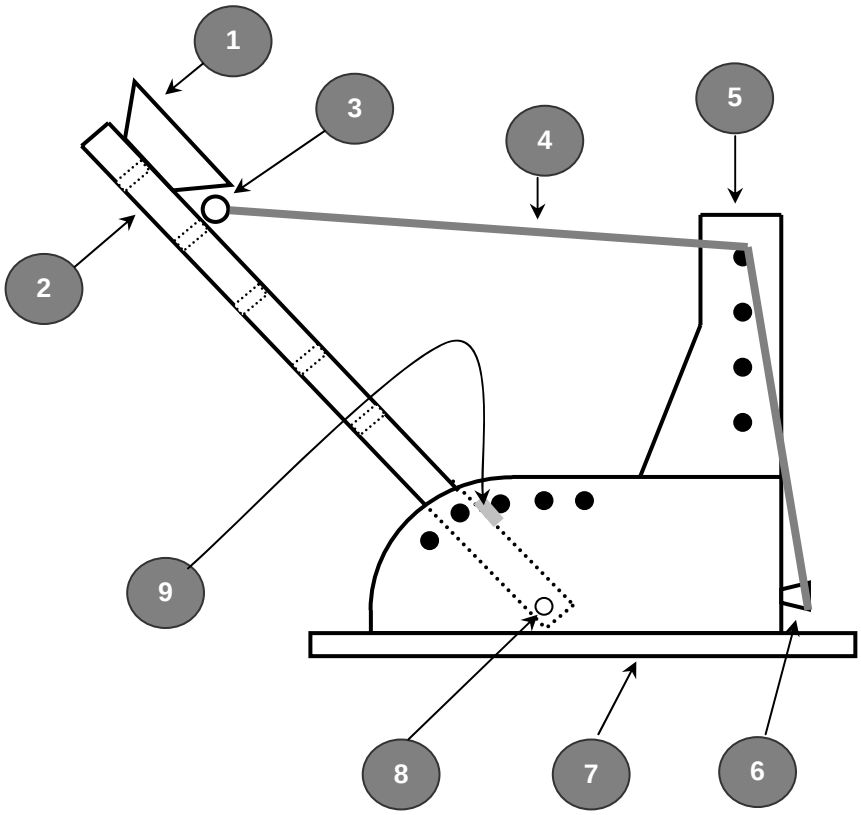
2. SIX SIGMA
   a) Registered (®) 1993 Motorola, Inc.
   b) Issues surrounding exclusive use

C. Copyrights generally



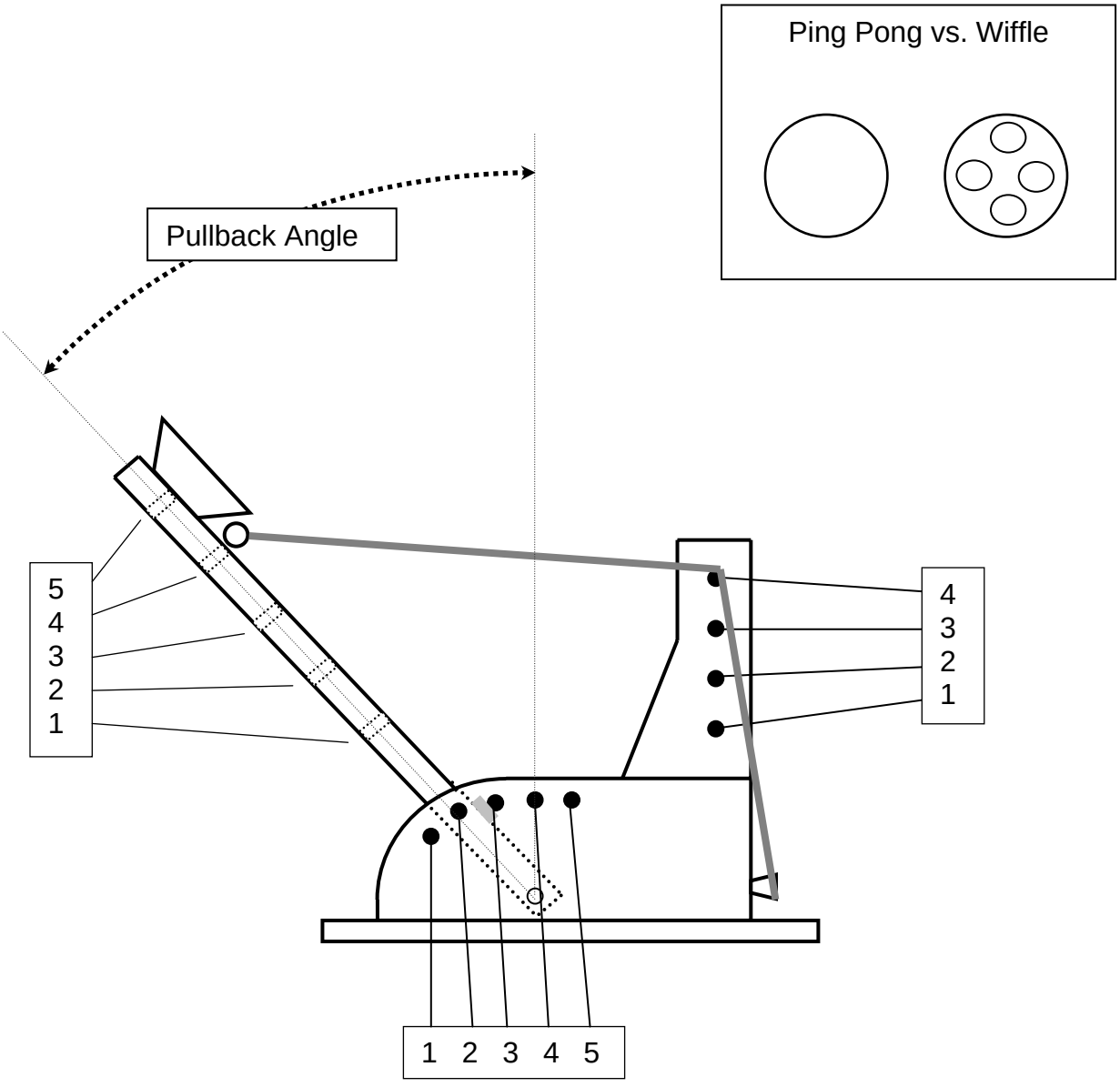
NOMENCLATURE

1. Cup
2. Pull Arm
3. Pull Pin
4. Rubber Band
5. Tower
6. Dowel
7. Base
8. Axis
9. Stopper



SETTINGS

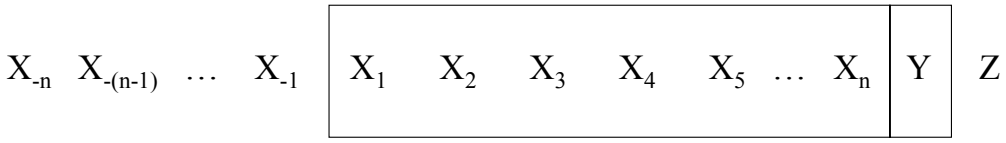
1. Pull Arm: Cup {5, 4, 3, 2}
2. Pull Arm: Pin {4, 3, 2, 1}
3. Tower Pin {4, 3, 2, 1}
4. Stop Pin {5, 4, 3, 2, 1}
5. Pull Back Angle {Continuous: 90^{O} to 180^{O}}
6. Ball {ping pong vs. wiffle}



II. Motivation

A. MBA course on Process Improvement
   1. Theory of Constraints
   2. Lean Thinking
   3. Six Sigma

B. Required Undergraduate Core Course (School of Business)
   1. "Management Science & Operations Management"
   2. Operations Management Model



Mission
Strategic Plan
Execution
Product/Service Design
Transformation
Forecasting
Capacity Planning
Scheduling/Aggregate Planning
Yield Management
Inventory Management
Supply Chain Management
System Dynamics
Project Management
Six Sigma
Theory of Constraints
Lean Thinking
JIT

III. Five Labs for the Catapult

IV. References

A. Reading Materials

1. "Evolutionary Operation", Box and Draper, J. Wiley & Sons
   a) Precursor to many of the ideas captured by Six Sigma
   b) Originally published in 1969
   c) Republished in 1998 in the Wiley Classics Library series

2. "Learning Statistics Using the Catapult", Breakthru Improvement Associates
   a) This is a thorough treatment of teaching statistics with the Statapult
   b) Excellent workbook approach
   c) Available at the NCMR website:

   http://www.ncmrcompany.com/TG1.pdf+-+Learning+Statistics+.pdf+version.html

B. Other Materials

1. Catapult –

   a) $224 NCMR:

   http://www.ncmrcompany.com/ST1+-+The+NCMR+Six+Sigma+Catapult.html

   b) $149 Roger Haug: 816 898 2578

2. XPult – http://www.xpult.com/

3. Balsa Wood Plane –

   http://www.guillow.com/GuillowDetail.asp?UID=3107283&Num=1&prod=26&SeriesId=12&FamilyId=2

   a) See "The Practice of Statistics: Putting the Pieces Together", John D. Spurrier, Duxbury Press, for balsa wood planes and response surface methods

C. Other Activities (focus on variation)

1. Beer Game

2. Flow Activity

Five Labs for the Catapult

Activity #1

A. Purpose: familiarity with the Catapult (and Six Sigma thinking)

B. Use a piece of paper and randomly place on floor

C. Try to hit the target
   1. first—how many tries will you need? _____
   2. second—do it
   3. third—how many tries did it take? _____
   4. fourth—move the target
   5. fifth—would what was learned in #2 help with new location?

D. Knowledge of shooting
   1. learn to hit one target—basic learning
   2. learn to hit any target—"profound" learning

E. Note on variation

   1. random variation is _____

   2. measurement variation _____

   3. systematic variation _____

Activity #2

F. Purpose: to analyze effects of changed materials in the supply chain

G. Settings
   1. stop pin at 3,
   2. tower pin at 4,
   3. pull pin at 4,
   4. use pull back of 160

H. Take as many shots as you think necessary with each of two balls
   1. how many shots did you choose for ball 1?
   2. same number of shots for both balls?
   3. record the data

Ball 1	Ball 2	(Ball 3)	…
___	___	…	
___	___		
___	___		
___	___		
___	___		
___	___		
___	___		
___	___		
…	…		

I. Questions

   1. Is there an impact on your operation with respect to the difference in the supplier materials?

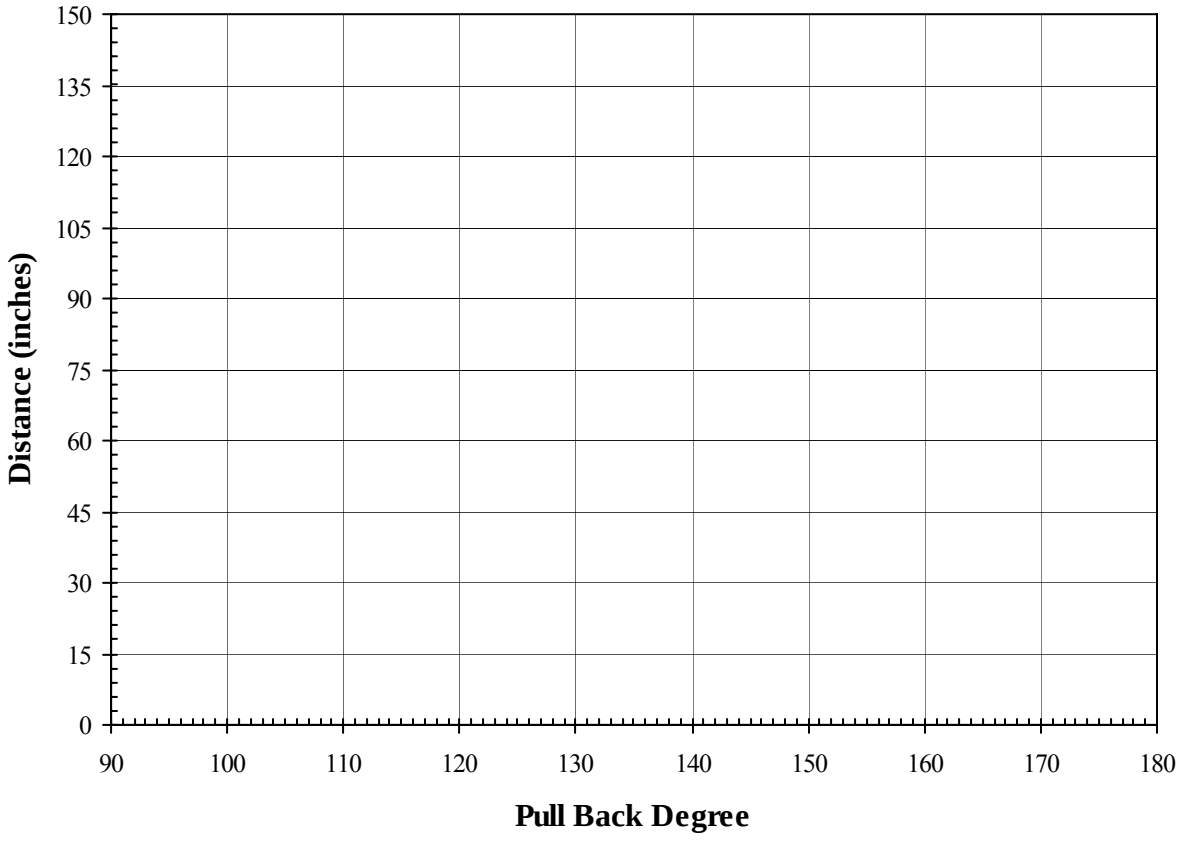
   2. How do you know?

   3. If there is no impact, might there be an impact at different settings?

Activity #3

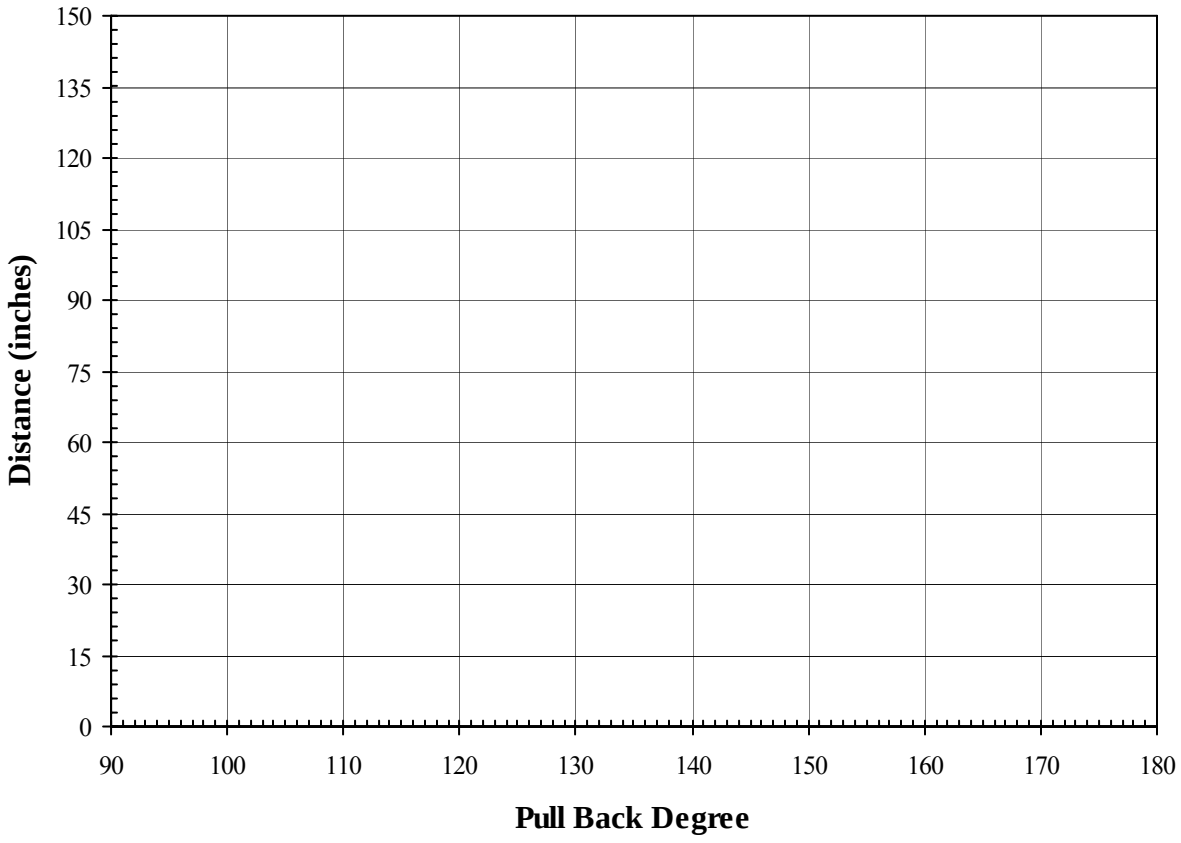
J. Purpose: to understand the relationship between pull back and distance
   1. what assumptions are you making? _____
   2. what analytical technique will you use? _____

K. Set stop pin at 3, tower pin at 4, pull pin at 4
   1. you choose 12 shots from any pullback
      a) 12 different pull backs with 1 shot at each pullback
      b) 6 different pullback with 2 shots at each pullback
      c) 4 different pullback with 3 shots at each pullback
      d) 3 different pullback with 4 shots at each pullback
      e) 2 different pullback with 6 shots at each pullback
   2. record your pullback and distance for twelve shots on the graph below.



Activity #4

L. Purpose: convert intuitive thinking into systematized analysis
M. Three shots at 4 settings
    1. Settings
        a) pull back at 140 and 170
        b) stop pin at 3 and 4
    2. Decide Standard Operating Procedures (SOP)
        a) Graph results
        b) Be creative in how you might visually display stop pin setting
        Perhaps "X" for stop pin at 3 / Perhaps "O" for stop pin at 4
        c) Explain variability influence on graph
            (1) Random variation
            (2) Measurement variation
            (3) Systematic variation
        d) At this point, connect the stop pin settings with a line from 140 to 170 for each of the two stop pin settings
            (1) Are the lines parallel __Yes __No
            (2) What does not parallel mean? _____
            (3) Using your graph, try to shoot one shot at ____ inches
            Shoot and calculate the difference between ideal and observed



Activity #5

N. Purpose: to understand the role of experimentation in operations management
O. Two factors with two levels:
    1. pull back angle: 140 and 180
    2. tower pin: 2 and 4
    3. stop pin at 4
    4. pull pin at 4
P. Choose two levels of each factor, call them low (-) and high (+) reflecting your beliefs about their impact on distance.
    1. For example, a choice of pullback of 140 degrees and 180 degrees would produce different distances: 140 would produce a shorter distance than 180 degrees, and therefore be labeled as low (-), whereas 180 would be high (+).
        a) For the pull back angle use 130 degrees and/or higher for both levels
    2. Your choice among the three options of pin settings ought to be pin settings 1 and 3 or 2 and 4—this is merely for convenience as we will see later
Q. Take two shots—according to your SOP—for each level for each factor (8 shots)

Factor A Pull Back Angle		Factor B Tower Pin				
(-)	140	(-)	2	___	___	average = ___a
(+)	180	(-)	2	___	___	average = ___b
(-)	140	(+)	4	___	___	average = ___c
(+)	180	(+)	4	___	___	average = ___d

R. Construct a model for shot distance with your data:

$$DISTANCE = \beta_0 + \beta_1 (A) + \beta_2 (B) + \beta_3 (AB)$$

$$\beta_0 = (a+b+c+d)/4$$
$$\beta_1 = [\ (b+d)/2 - (a+c)/2\ ] / 2$$
$$\beta_2 = [\ (c+d)/2 - (a+b)/2\ ] / 2$$
$$\beta_3 = [\ (a+d)/2 - (b+c)/2\ ] / 2$$

DISTANCE = __ + __(A) + __(B) + __(AB)

S. Test your model (using your SOPs)
    1. how to do this?
    2. how to interpret results?
    3. shoot for ____ inches
        a) use your model above where A = [-1, 1] where a "-1" represents your low (-) level for the pullback angle; a "+1" represents your high level (+)
        b) use your model above where B = [-1, 1] where a "-1" represents your low (-) level for the pin setting of the factor you had chosen for B; a "+1" represents your high level (+)
    4. your shot: _____ inches, producing a difference of _____