




The Magic of Multifactor Testing





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Maximizing this educational opportunity



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- Slides posted to www.statease.com/webinars/ with link to
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 *Please press the raise-hand button if you are with me.*

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The WIIFM (What's in it for me)

- ❖ This presentation spells out a fun physics experiment that illustrates the advantage of multifactor design of experiments (DOE) over the standard one-factor-at-a-time (OFAT) scientific method.
- ❖ Via this delightful example, it shows how two-level factorial DOE reveals surprising interactions that cannot be detected OFAT.
- ❖ See how my grandson Archer and I uncovered multiple interactions that surprisingly canceled out OFAT main effects. Our home experiment on bouncing balls affirms the application of DOE for building profound data-driven process knowledge.

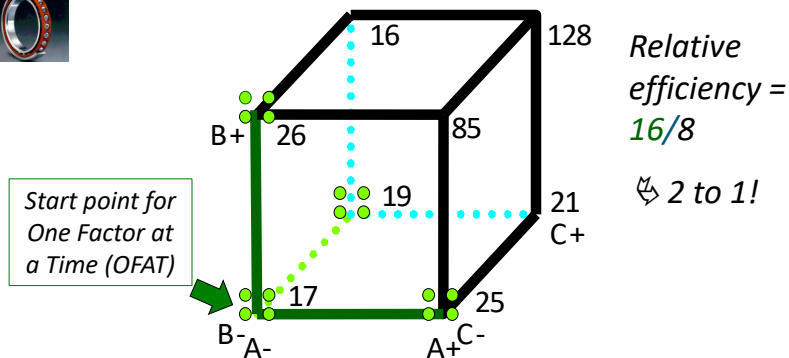
Whether you are new or experienced at doing DOE, this talk will provide inspiration to abandon OFAT in favor of multifactor methods.

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Multi-Factorial (VS OFAT) a la George Box* (1/2) (SKF bearing life in hours from accelerated test)



*"George's Column," *Quality Engineering*, Vol. 2, No. 3, p365.

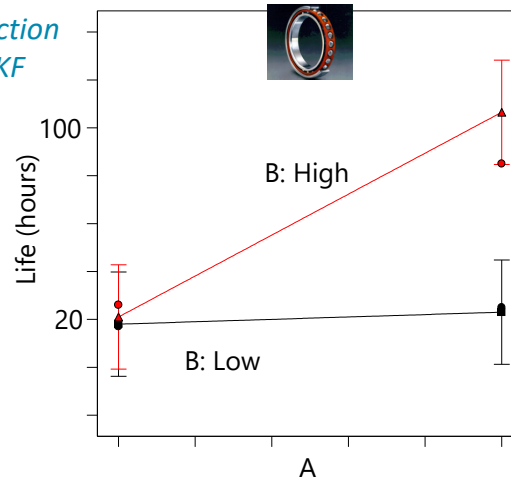
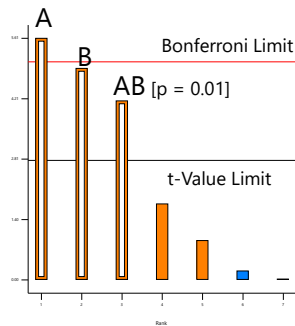
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Box's Bearing Case (2/2) Significant Effects & Interaction Plot

This breakthrough interaction led to 300% increase in SKF bearings' service life.*



* "Breaking the Boundaries," *Design Engineering*, Feb 2000, pp 37-38.

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DIY DOEs to Demonstrate Interactions (1/3) Hard to reliably produce in hands-on exercises

- Prototype propellers made from plastic cups (Izraelevitz, Anderson-Cook, and Hamada⁸): Minor interactions can between the number, angle and of length of the blades; but only by with very precise procedures and complete replication for sufficient power.



* "Illustrating the Use of Statistical Experimental Design and Analysis for Multiresponse Prediction and Optimization," *Quality Engineering*, 23:265–277 (2011).

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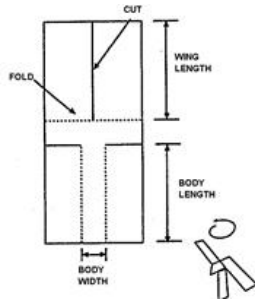
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DIY DOEs to Demonstrate Interactions (2/3)

Hard to reliably produce in hands-on exercises

- 👉 Paper helicopters (Box²): Generally dominated by one big main effect—the wing length. An interaction emerges by using very heavy card stock, which ruins flight performance regardless of wing length.



* “Teaching Engineers Experimental Design with a Paper Helicopter,” Report #76 (1991), Center for Quality and Productivity Improvement, University of Wisconsin, Madison.

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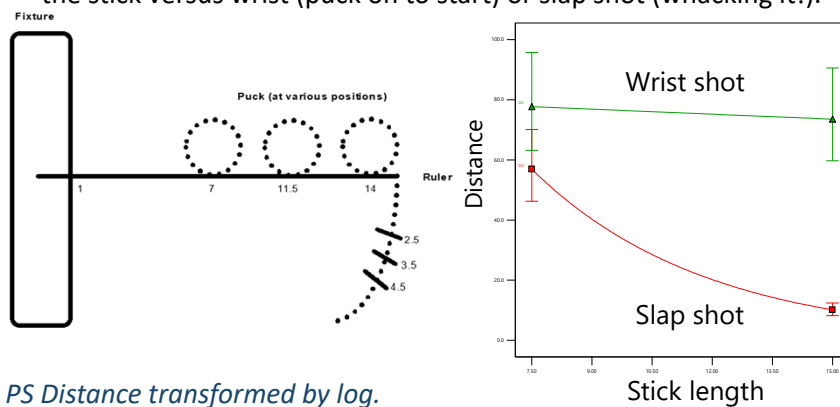
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DIY DOEs to Demonstrate Interactions (3/3)

Hard to reliably produce in hands-on exercises

- 👉 Tabletop hockey (Anderson): One reliable interaction—the length of the stick versus wrist (puck on to start) or slap shot (whacking it!).



PS Distance transformed by log.

* “Tabletop Hockey Meets Goals for Teaching Experimental Design,” ASQ Statistics Division Newsletter, Volume 26, No. 3 (2008).

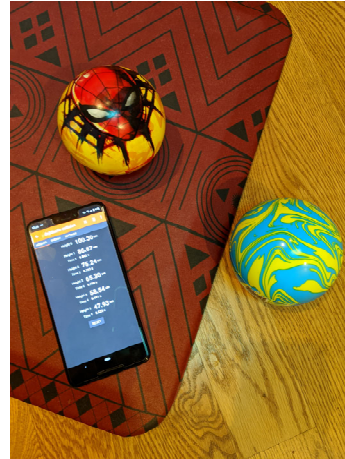
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Experimenting on 'Elastic Spheroids'* *Surprisingly educational*

- Rubber balls readily attainable
- Cell-phone app provides precise timing of bounce by sound
- Fun project to do with students (*such as my grandson!*)
- These factors strongly interact:
 - A. Type of ball: Hollow ("Spidey") vs Solid ("Swirly")
 - B. Storage temperature: Room vs Freezer
 - C. Height of drop: 3 – 6 feet
 - D. Flooring: Wood vs Rubber

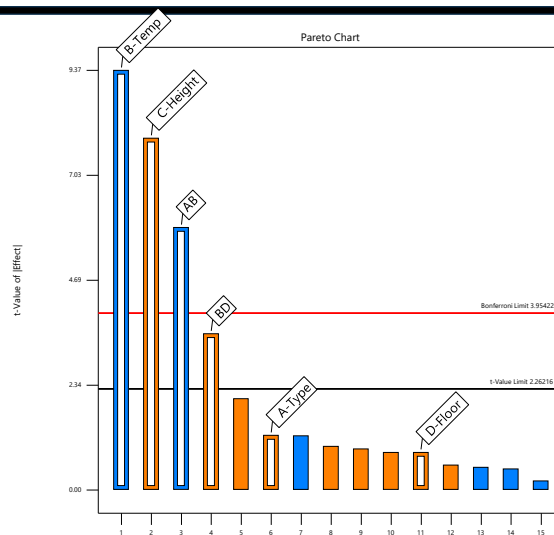


*Not Missing A Trick, Fun Physics Experiment Reveals The Magic Of Multifactor DoE Testing, Mark J. Anderson, *Quality Progress*, May 2022, Volume 55, Issue 5, pp. 32-39.
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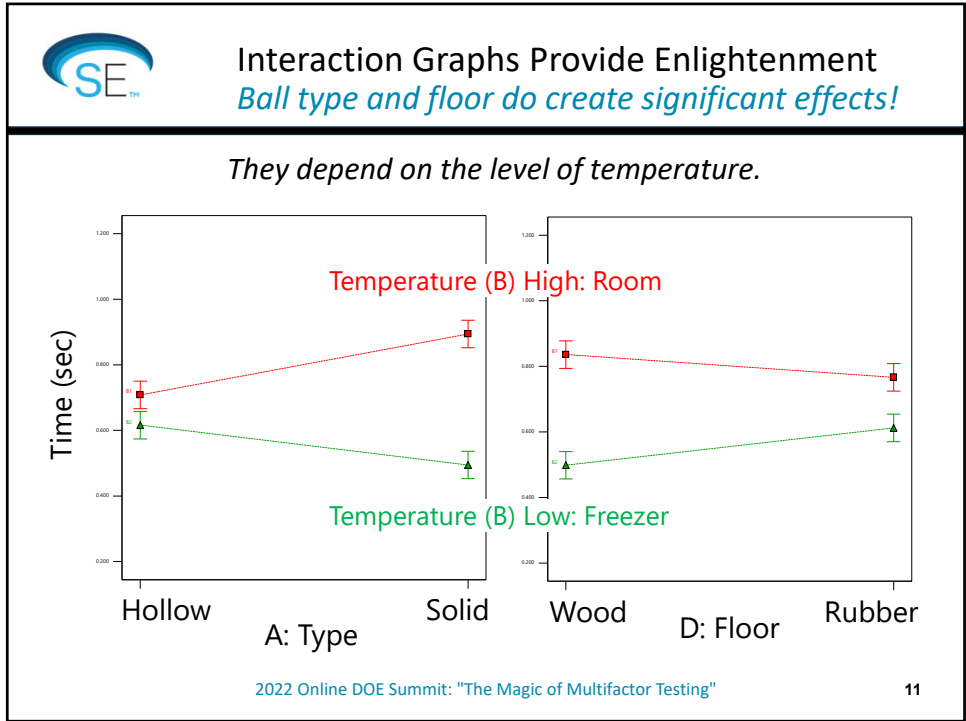


Pareto plot of effects *Surprise! Ball type (A) & floor (D) insignificant.*



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SE™ Design & Analysis of Elastic Spheroid DOE
Made easy by Stat-Ease software

DX

*Bouncing balls
Rebuild, re-open & analyze*
Show main effects A and D

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 *Do you agree?*

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'Elastic Spheroids'

Details on experiment, physics & ideas for future

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<p>Industry:</p> <p>All <input type="text"/></p> <p>Content:</p> <p>Home Experiment <input type="text"/></p> <p>Statistical Tool:</p> <p>All <input type="text"/></p> <p>Featured Author:</p> <p>None <input type="text"/></p>	<p>Not Missing a Trick, Fun Physics Experiment Reveals the Magic of Multifactor DoE Testing</p> <p>Published: May 2021 Author: Mark Anderson</p> <p>This article details a delightful experiment that can be done at home or in class to illustrate the advantage of multifactor testing over the traditional one-factor-at-a-time (OFAT) scientific method. It uncovers multiple interactions that surprisingly cancel out OFAT main effects.</p> <p>Publication: Quality Progress</p>
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Enjoy! Consider DIY. If so, let me know how it goes.

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Other fun and educational DOEs

Download this list of dozens of enjoyable hands-on projects from the same "Home Experiment" site.



DOE It Yourself

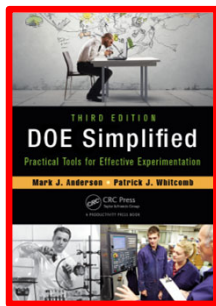
Fun science projects compiled by Mark J. Anderson, Principal, Stat-Ease, Inc.

Give design of experiments a try! These are my favorites for doing at home or in class – in no particular order. You don't need any unusual equipment. The details are sketchy, but they should be sufficient. Use your imagination*! If you have your own favorite DOE that anyone can do, send me the details. I'll add it to the list.
---Mark

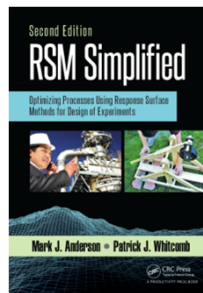


References*

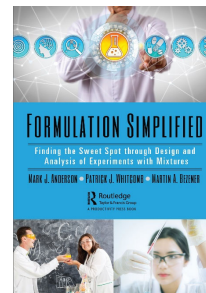
3rd edition 2015



2nd edition 2016





1st edition 2018



* Taylor & Francis/CRC/
Productivity Press
New York, NY.



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