Mathematics For Measurement: “Math for practical arts”
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Slides and detailed materials at www.austincc.edu/mparker/talks/jan06mm/

OUTLINE OF TALK:

What: An accessible, stand-alone mathematics course using a theme of measurement to provide tools for thinking and communicating mathematically

By whom: A math/statistics teacher interested in technical education and an application scientist experienced in industrial measurement interested in math/science education

For whom: College students who need only one math course for their degree.

What is taught: practical trigonometry, modeling, error analysis (bias, noise, sensitivity, propagation)

Why: Learn to analyze and solve measurement problems, and to talk with colleagues about them.

How (tools): Algebra (linear and proportional equations), formulas (including non-linear), spreadsheets, graphing (with spreadsheet), diagram construction (simplified technical drawing)

How (tactics):
• Connection between algebraic, numerical, and graphical representations
• Use of alternate representations to check answers instead of “look in the back of the book.”
• Cross-connections between the major strands of the course.

How (strategy): Sophisticated application of simple techniques
Example: techniques: spreadsheets & graphing → application: curve-fitting & residual analysis
Example: technique: diagram construction → application: solving geometric / trig problems

A hunter is lost in a forest, but can communicate by portable radio to two ranger stations. The rangers at each station figure out how far away he is from them by how long it takes the sound of a shot to reach them through the air after hearing it through the radio. Station A is 5.1 miles due west of Station B, and the hunter is 4.6 miles from Station A and 3.7 miles from Station B. Construct a diagram indicating the possible locations of the hunter.

Spiraling topic sequences:
• Approximate numbers → rounding → intervals → error propagation
• Data → fitted curve → residuals → standard deviation
• Formula → graph → solutions → numerical zoom
• Linear equations → graphs → slope → error sensitivity
• Word problems → diagram construction → right-angle trigonometry → general trigonometry
• Noise → std dev → Noise in averaged measurements → other measurement combinations
• Solving equations → word problems (linear equations) → word problems (trigonometry)

Surprises: student enthusiasm about using spreadsheets, impact of diagram construction on word-problem capability

Planned next steps: more simulations, more applications (case studies from faculty), measurement labs/demonstrations, expand to more majors.
PART 1. (4 WEEKS) – REVIEW AND BASIC TOOLS
   Algebra Review - Solving Equations and Evaluating Expressions
   Rounding
   Using a Calculator
   Formulas - Computing and Graphing
   Using a Spreadsheet
   Angles and Construction of Diagrams
   Linear Equations - Algebra
   Linear Models - Word Problems
   Introduction to Data and Modeling
   Propagation of Errors due to Rounding

PART 2: (3 WEEKS) – BASIC TRIGONOMETRY & USE OF APPROXIMATIONS
   Introduction to Trigonometry
   Trigonometric Ratios and Relationships
   Computing with Approximate Numbers: Significant Digits
   Measurement Sensitivity: Sensitivity of a Formula to Errors in Input Values
   Communicating the Results of Computing with Approximate Numbers

PART 3: (5 WEEKS) – MEASUREMENT NOISE & GENERAL-TRIANGLE TRIGONOMETRY
   Curve Fitting: Separating "Signal" from "Noise"
   Describing Noise in Measured Values: Standard Deviation
   Propagation of Noise I: One Measured Input Value into a Formula.
   Sine and Cosine Formulas on Larger Intervals
   Solving General Triangles
   The "Ambiguous Case"

PART 4: (4 WEEKS) – CORRECTION AND COMBINATION OF MEASUREMENTS
   Removing Bias from a Measurement Process: Calibration
   Propagation of Noise, Part II: Averaging Multiple Measurements – A Useful Rule
   Propagation of Noise, Part IV: Combining Measured Input Values – Other Rules

Solving Applications Problems (students select project problems from teacher-supplied list)