Engineering Design
ENGR 13x2

Engineering Tools I

Agenda

- Estimation
- Working with Numbers
  - Units
  - Sig Figs
- Dimensioning & Tolerancing
- Types of Graphs

Engineering tools

The purpose of this chapter is to highlight some of the knowledge tools, software tools, and procedural tools that are found in the designer's "toolkit."

- Some topics discussed in this chapter
  - Estimation
  - Working with numbers
  - Graphing
  - Prototyping
  - Reverse engineering
  - Computer analysis
  - Spreadsheets
  - Solid modeling and CAD
  - Simulation

Estimation

- Incredibly powerful tool
  - Quick, “back of the envelope” (BoE) calculations -- approximation is OK!
  - Set the boundaries of what is “reasonable”
  - Requires good engineering judgment
- An example . . .

My friend's truck needs to be painted . . .

How much paint do we need to buy? (5 gal? 1 gal? 1 qt?)

Estimate the paint required

Estimate the paint required

Practice

- How many party balloons can you fit in this lecture room?
  - *Along with your estimate, be sure to state any assumptions you made!*

Working with numbers

- Engineers work with numbers
  - Units
  - Reconciling units
  - Significant figures

Units

- Nearly every calculation will involve the use of units
  - SI units and English
  - Consistency is critical
  - Prefixes for SI *(see Table 4.1 & 4.2)*
    - milli => 10^{-3}, micro => 10^{-6}, nano => 10^{-9}, …
    - kilo => 10^{3}, mega => 10^{6}, giga => 10^{9}, …
  - Unit reconciliation
    - At the end of your calculation, your units should be correct (i.e. m^3 for volume)
    - Good check for your calculations

Unit reconciliation - example

- Volume of a cylindrical tank
  - $V = \pi r^2 h$
  - Units of r = *m*
  - Units of h = *m*
  - $m^2 \times m = m^3$ (appropriate units for volume)
- Ideal gas law
  - $PV = nRT$
  - In SI units, R (gas constant) = 8.314 J/mol·K
    - What units should be used for P, V, n, and T?

Significant figures

- What is "significant"?
  - Any non-zero digit
  - Zeros, EXCEPT:
    - Leading zeros that serve as "placeholders" to indicate the scale of a decimal number (<1) are <u>not</u> significant.
    - Trailing zeros that serve as "placeholders" to indicate the scale of a number are <u>not</u> significant
  - Note that trailing zeros to the right of the decimal point <u>are</u> significant
- How many sig figs?
  - 1208.1
  - 0.50
  - 0.0254
  - 52,000,000
  - 52.0 x 10^6

Sig figs - precision

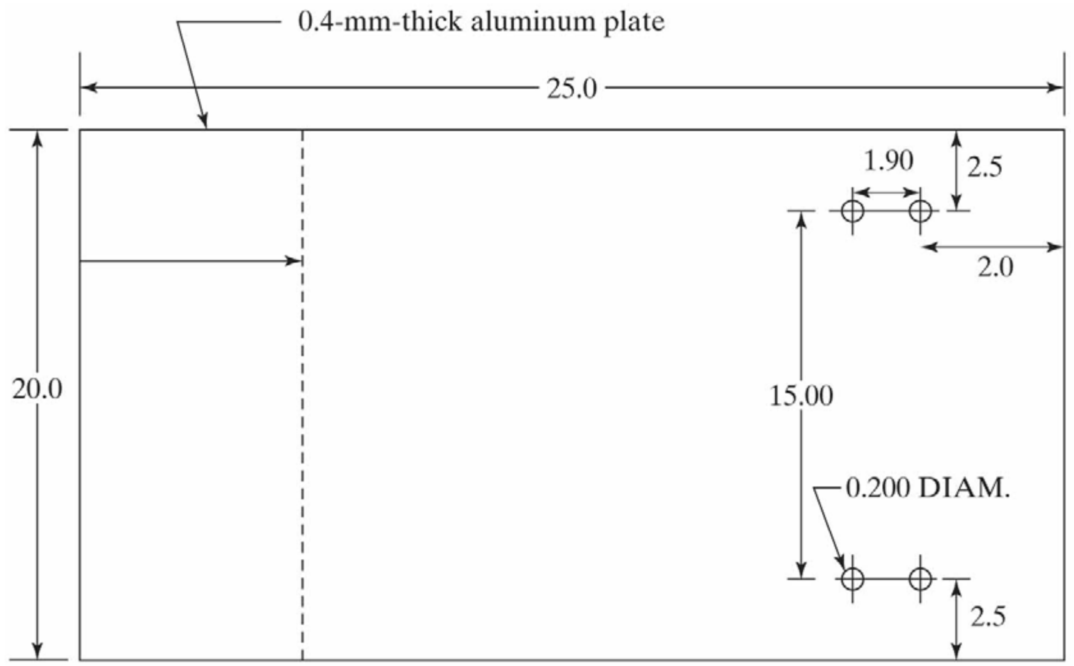
- Precision
  - A number cannot be more precise than its least significant digit
  - A quantity cannot be specified with more precision than its measured precision
  - The precision of any calculation is determined by the least precise number in the calculation
- What is the proper answer to this equation?

  127 x 0.50 / 5.3 =
- Calculator produces 11.98113
  - => answer should be reported as **12**
  - Don't let your calculator fool you!

Dimensioning and tolerances

- No part can be machined to exact dimensions
  - Why?
- The *tolerance* on a dimension specifies the acceptable degree of error in the fabricated part
- Tight tolerances are more expensive
  - Why?
  - You must decide which dimensions are critical and worthy of the extra cost.

Figure 4.4 Support plate with dimensions and tolerance table.



Main chassis plate

Tolerance table	
All dimensions in cm	
X	±0.5
X.X	±0.1
X.XX	±0.05
X.XXX	±0.001

Graphing

- Be familiar with these graphing types (outlined in section 4.3) and when you would use each
  - x-y
  - Semi-log
  - Log-log
  - Polar
  - Three-dimensional

Figure 4.5 Examples of *x-y* plots having simple linear scales.

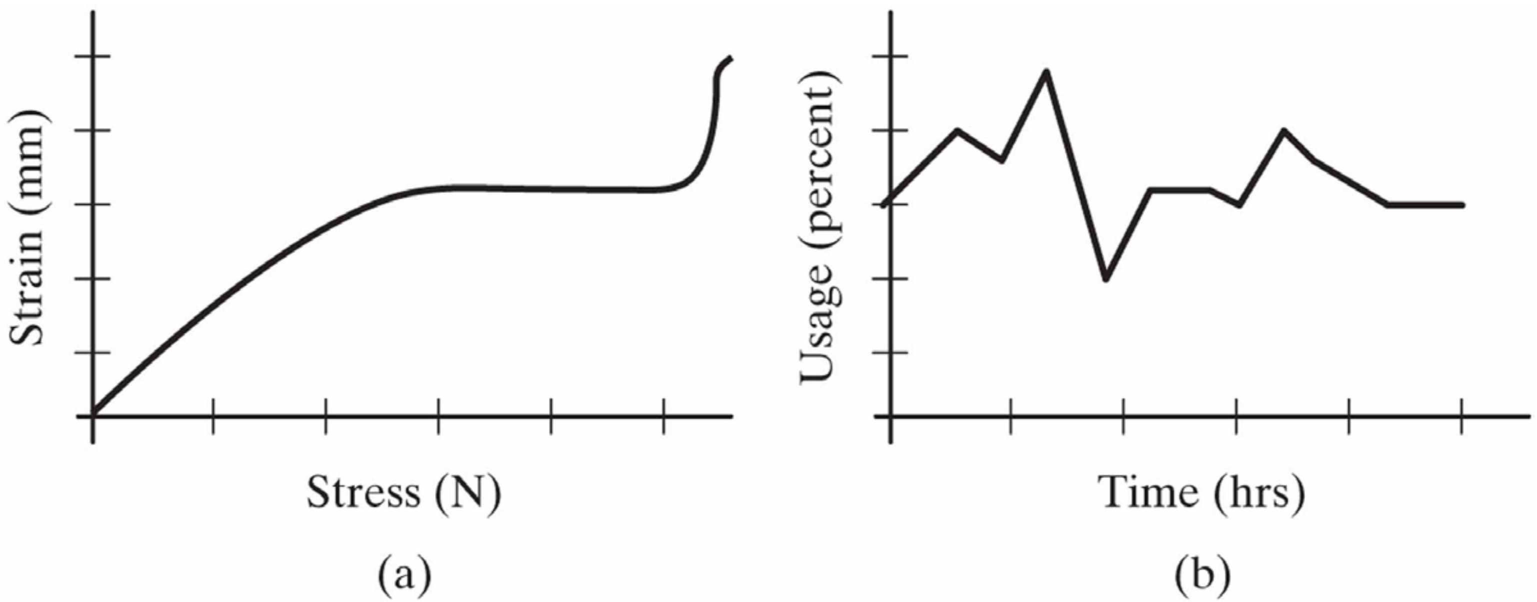


Figure 4.6 Plot of cell density versus time. Both axes of the graph are linear.

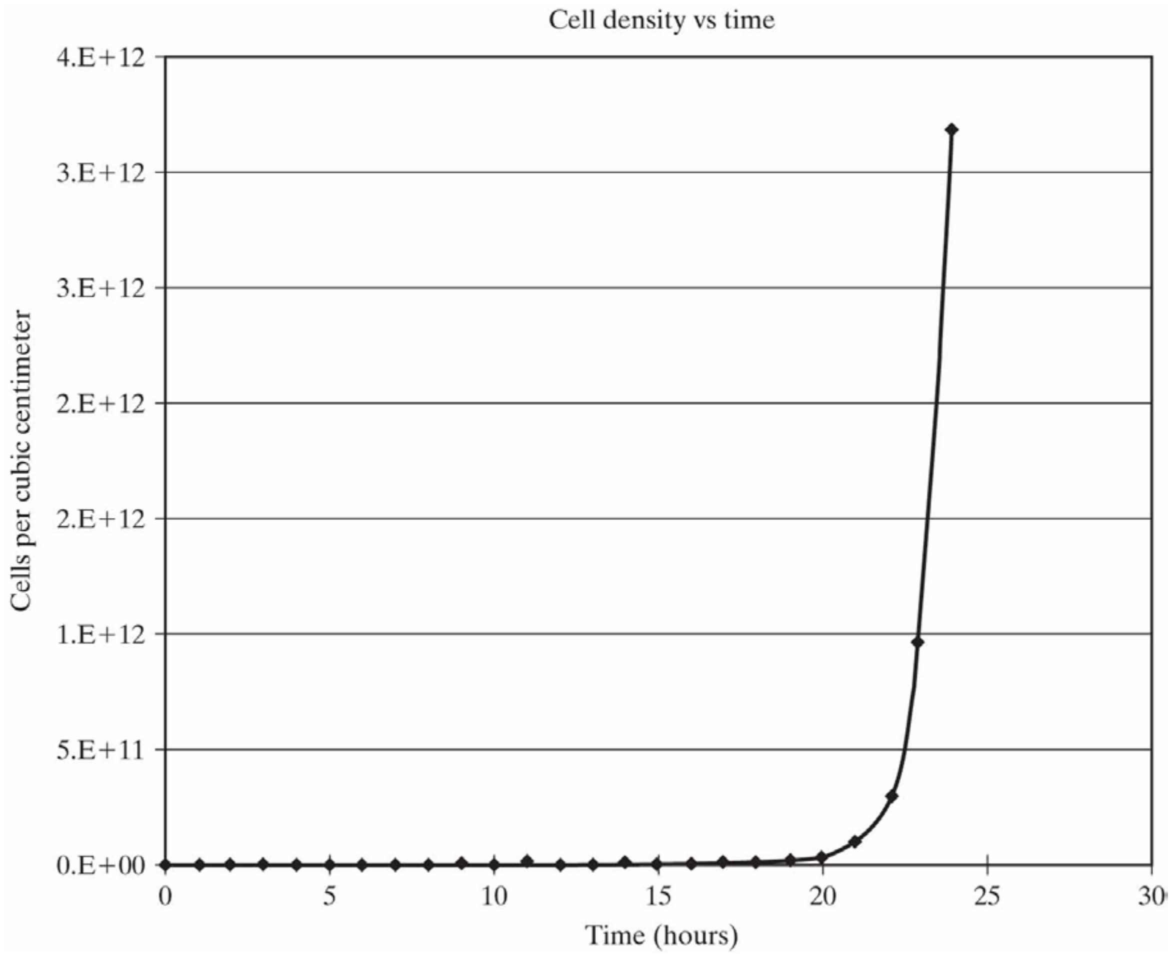


Figure 4.7 Data points of Table 4.3 plotted on a semilog graph. Because the cell density increases exponentially with time, using a logarithmic vertical axis allows more points to be included in the range of the graph.

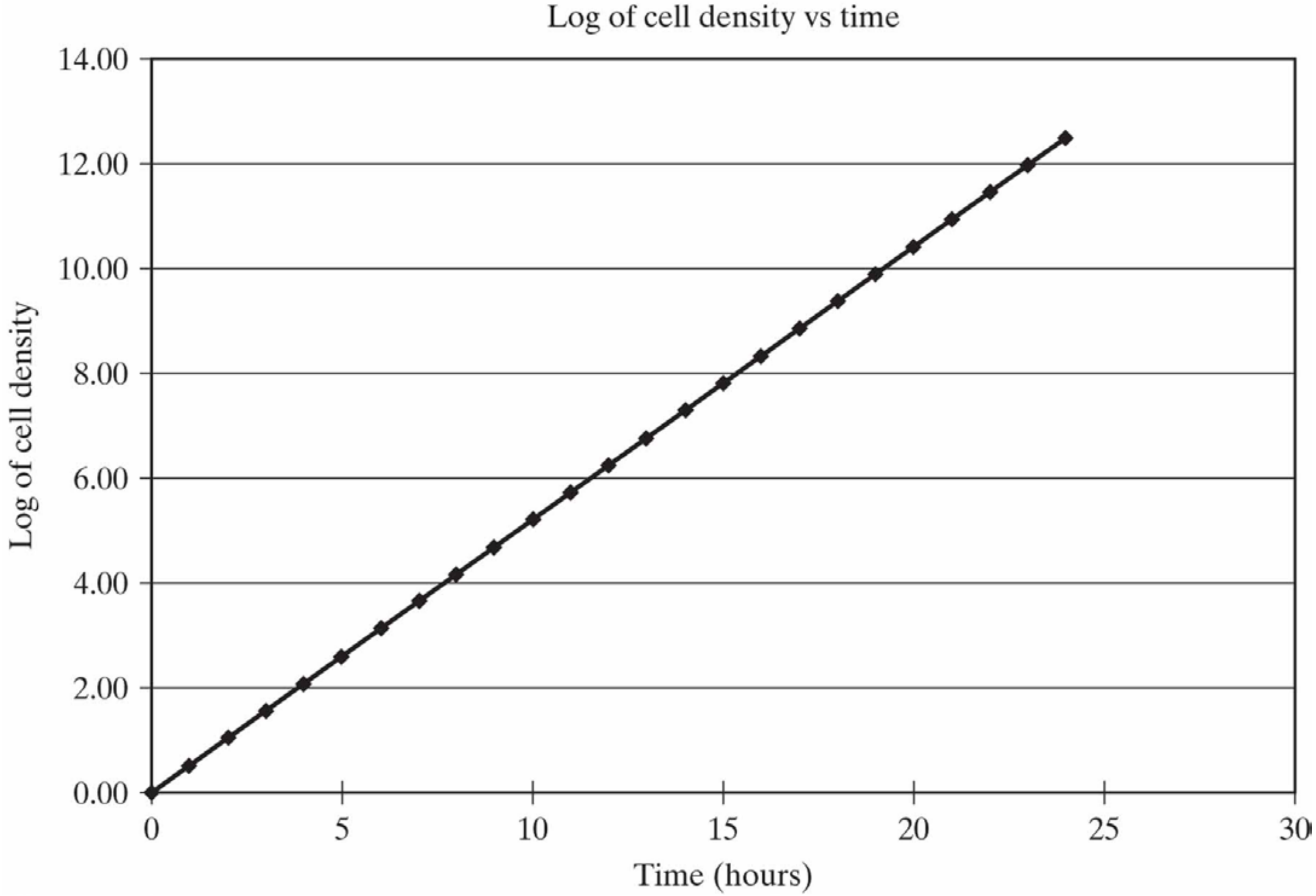


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Figure 4.8 Response of a car suspension system to a constant magnitude stimulus of varying frequency. In this case, both scales are best represented logarithmically.

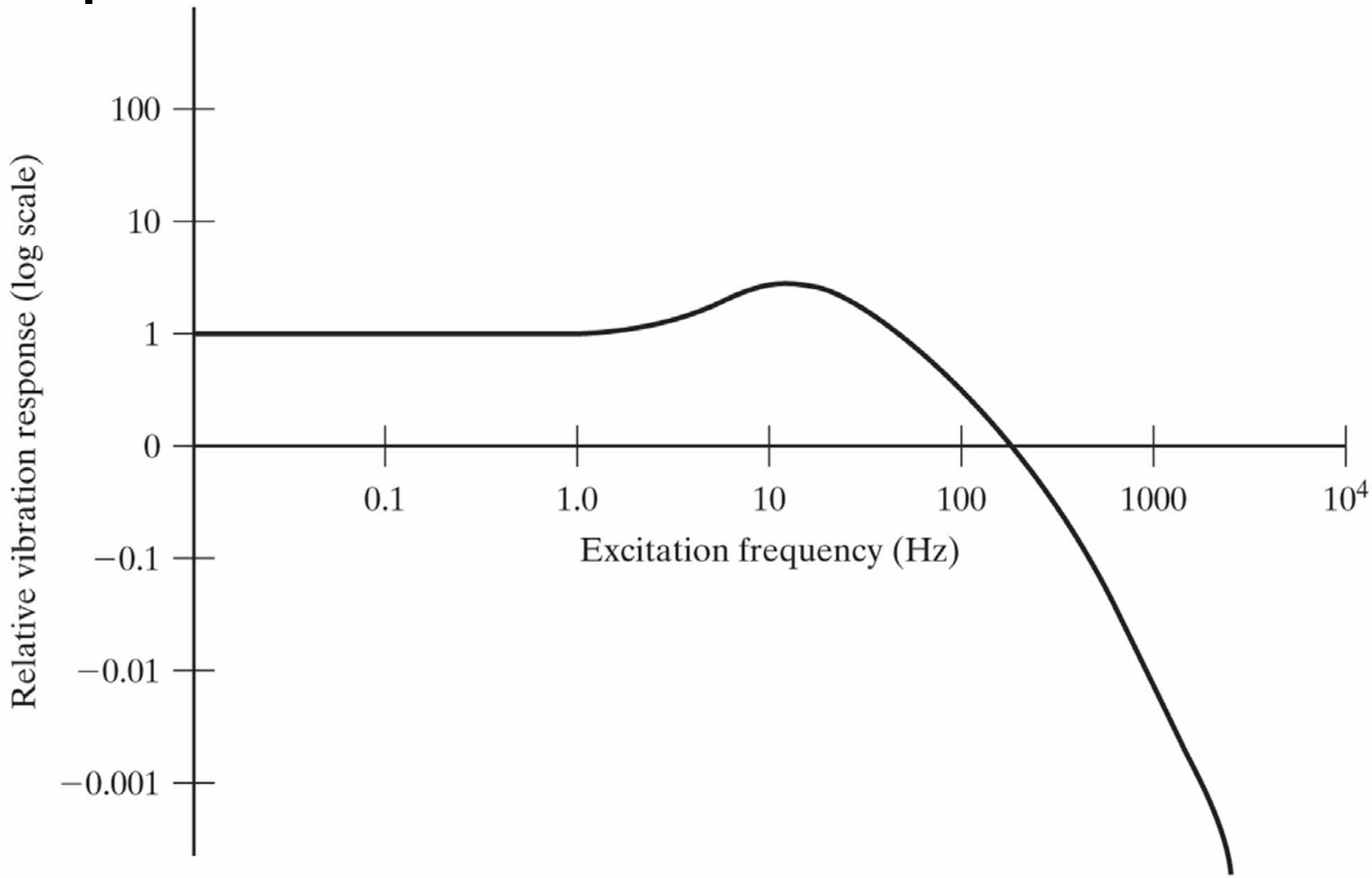

Figure 4.9 Polar plot of antenna pattern. The length of the vector from the origin represents the strength of the reception at a given angle θ.

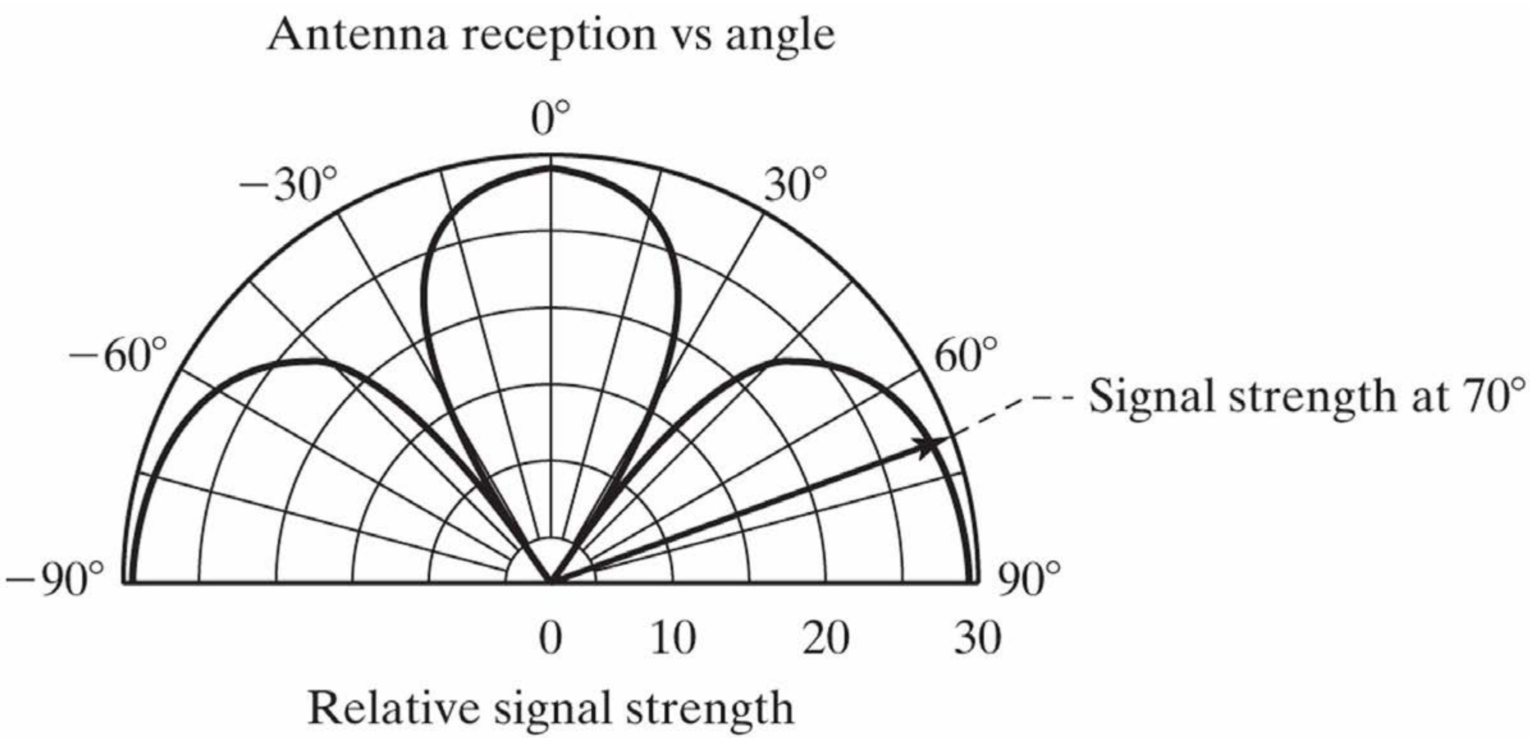

Figure 4.11 Isometric plot of the height of a semiconductor surface as a function of position *x*-*y* over the plane.

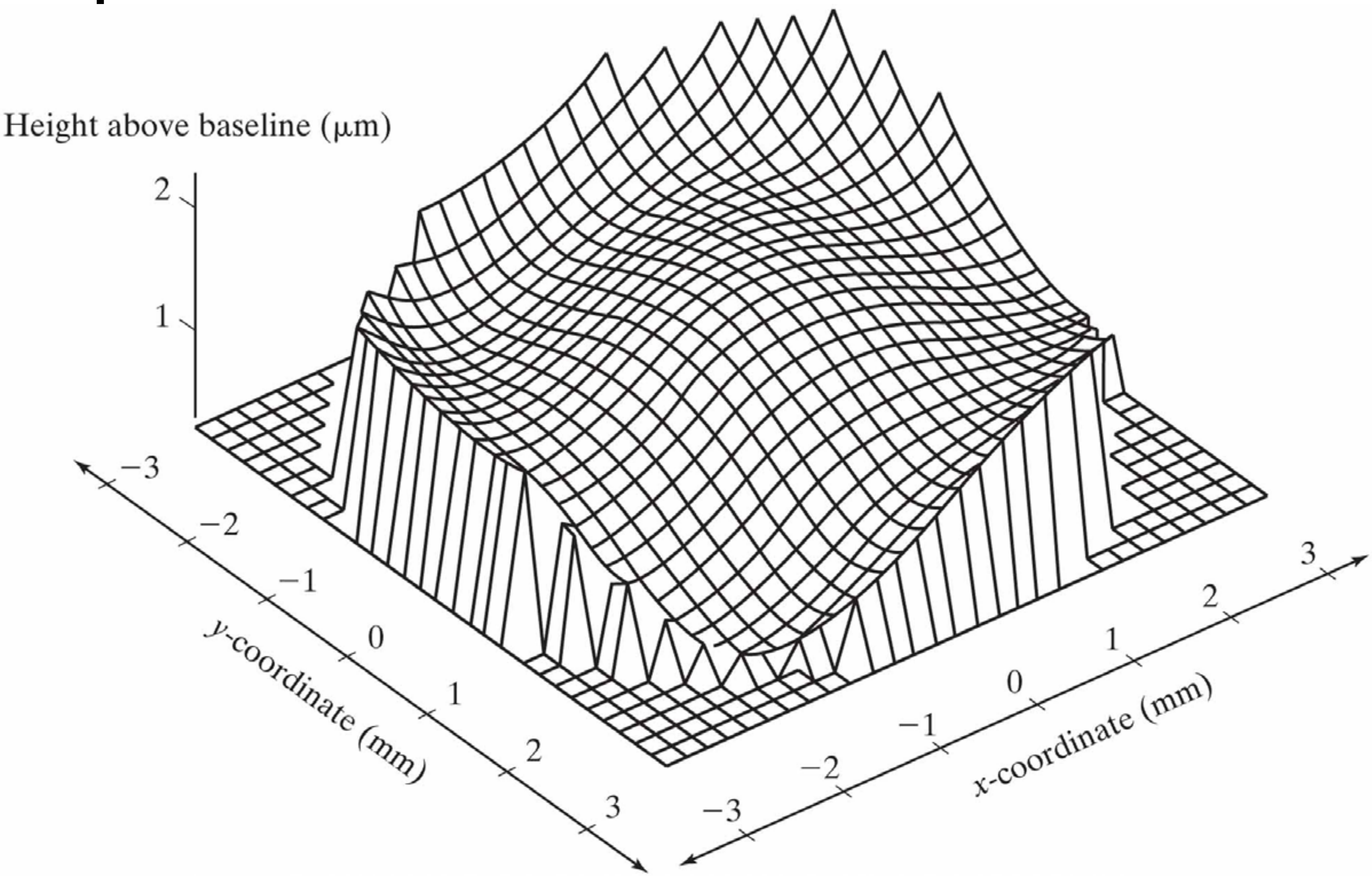

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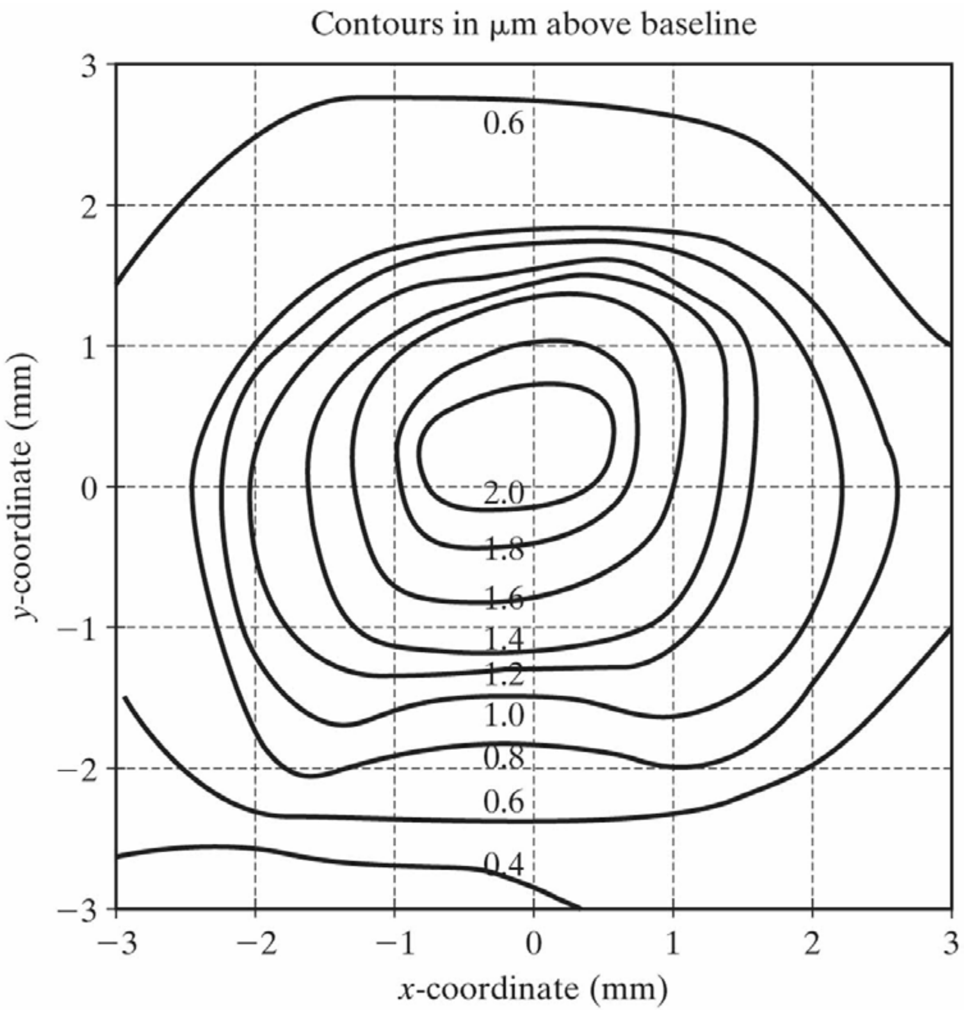
Figure 4.12 Example of a contour plot. The isobars indicate the surface profile of a silicon chip.



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