I. Changing Face of Computing and the Task of the Computer Designer
   a. Desktop Computing
      i. Optimize price-performance
   b. Servers (Web)
      i. Availability
      ii. Scalability
      iii. Throughput
   c. Embedded Computers (fastest growing portion of computer market)
      i. Price!
      ii. Minimize memory
      iii. Minimize power

II. Architecture
   a. Instruction set architecture
   b. Organization-high level aspects of a computer's design
      i. Memory system
      ii. Bus structure
      iii. CPU design

   Note: Pentium II and Celeron are nearly identical: different clock rates and memory systems

III. Technology Trends
   a. Integrated circuit logic technology
      i. Transistor count growth 55% per year
      ii. Dram density: 40-60%/year
         1. Cycle time improving slowly
         2. Bandwidth improvement 2X latency
      iii. Magnetic Disk Density 100%/year
         1. Access time only 1/3 in 10 years
      iv. Network bandwidth doubling every year
   b. Processor lifetime ~5 years
      i. 2 years in development
      ii. 3 years in production
   c. Cost decrease about rate that density increases

IV. Scaling of Transistor Performance, Wires, and Power in IC's
   a. Feature size: 10μ 1971 to 0.18μ in 2001
      i. Performance increases linearly with feature size
      ii. Improved density yielded
         1. Increased bus size
         2. New features such as on-board cache
      iii. Density increases quadratically with deacreasing feature size
      iv. Wires get worse with decreased size
         1. Copper–>One-time improvement in delay
         2. Wire delay greater limitation than transistor delay
            a. Pentium 4 allocated 2 stages of pipeline for wire delay
   b. Power
      i. May become greater limitation than transistor count

        ii. First μProcessors: .1 Watts
            Pentium 4: 100 Watts

V. Cost Price and Their Trends
   a. Impact of Time, Volume, Commondification
      i. Figure 1.5: Learning Curve (measured by change in yield)
         Cost of DRAM will drop by a factor of 5 during 2 year development
      ii. Volume: Cost decreases 10% for each doubling of volume
      iii. Commondification (Products sold by multiple vendors in large volumes
      iv. Competition decreases the gap between cost and selling price
   b. Cost of an integrated circuit
      i. Becoming a greater percentage of system cost
      ii. Cost has decreased exponentially, but basic process unchanged
      iii. Sole factor in designer's control: die size
         1. Cost of die grows with fourth power of die size
            a. Exclude functions, I/O pins
         2. Masks may exceed $1 Million; Small volume can be significant part of production cost!
   c. Distribution of cost in a system
      i. Dram memory 1/3 total cost
      ii. Monitor 1/3 total cost
   d. Cost versus price
      i. Must understand to know impact of deleting components
      ii. Gross margin: can't be billed to one product
         1. Marketing, sales tax, R&D cost, mfg. equip. repair, building rental, financing cost, pretax profit, tax
      iii. Direct costs + gross margin + component costs = selling price
      iv. Gross margin increases with uniqueness (usually 10-45%)
      v. List price – discount = average selling price
      vi. 4-12% of company income spent on research
         1. Companies with 15-20% rarely prosper
      vii. Large expensive machines
         1. cost more to develop
         2. less sold
         3. need greater gross margin
   e. High performance design may have price as no object!!
   f. PC market is cost-performance design
   g. Embedded market has low-cost design

VI. Measuring and Reporting Performance
   a. Possible measures
      i. Response time: start to completion time
      ii. Throughput: total amount of work done in given period
      iii. Only consistent and reliable measure is execution time of real programs!!