

## A

- Aaker, David A., 57
  - Abscissa, 687
  - Absolute cell address, 676
  - Accountability 106-107, 148
  - Acid Rain 133
  - Acme thread, 593
  - Active cell, 663
  - Active worksheet cell, 657, 661
  - Activities-on-node PERT chart, 165-166
  - Actual size, 524
  - Adams, Donald D. 134
  - Adding worksheet items, 658
  - Addition operator, 664
  - Additive technique, 281
  - Address:
    - absolute, 676
    - cell, 655, 676
    - relative, 676
  - Adjacent areas, 383-384
  - Adjacent views, 349-351
  - Adjustable suspensions, 484
  - Aggregate concepts, 92
  - Agile design, 435
  - Agile manufacturing, 433
  - Aircraft Company Employee as FAA Inspector 118
  - Alberti, Leon, 446
  - Alger, J. R., 92 OR 93
  - Algor, Inc., 189
  - Aligned dimensions, 508, 509
  - Aligned sections, 390, 486-487
  - Alignment of features, 349-352
  - Alignment of views, 352
  - Allen, Thomas J., 26, 174, 178
  - Allowance, 524-525
  - Alpha prototypes, 16
  - Alphabet of lines, 202-204, 353
  - Alternate four-center ellipse method, 443-444
  - Alternate text styles, 271-272
  - Altshuller, Genrich, 79
  - Alvin & Co., 201, 206, 209
  - American Cylinders, 587
  - American National Standards Institute (ANSI), 192, 299
    - standards
      - bolts, hex, metric, A-28
      - cap screws
        - drill and counterbore sizes, A-26, A-27
        - hex, A-17, A-29
        - slotted fillester head, A-25
        - slotted flat countersunk head, A-25
        - slotted round head, A-25
        - socket head, A-26, A-28
        - hex, A-26
      - 1960 series, A-18
      - spline, A-26
    - dimensioning, 520-522
  - fits
    - clearance locational (LC), A-6
    - force and shrink (FN), A-9
    - interference locational (LN), A-8
    - limits and, metric, 529-534
    - running and sliding (RC), A-5
    - transitional locational (LT), A-7
  - keys
    - gib head, A-43
    - plain head, A-43
    - Woodruff, A-41, A-42
  - for multiview drawings, 389-391
  - partial views, 389-390
  - removed views, 391
  - revolution conventions, 390-391
  - nuts
    - hex
      - heavy, A-22
      - machine screw, A-24
      - metric flange, A-23
      - metric jam, A-22
      - slotted metric, A-23
      - styles 1 and 2, metric, A-22
    - square machine screw, A-24
  - pins
    - chamfered, A-44
    - clevis, A-46
    - cotter, A-46
    - square end, A-44
    - taper, A-44
  - pipe threads, taper (NPT), A-35
  - screws
    - cap; *see* cap screws *above*
    - machine, A-24, A-30, A-31
    - set, A-32, A-33, A-34
    - shoulder, A-27
  - sheet sizes, 299
  - title blocks, 583
  - washers
    - lock
      - external tooth, A-40
      - helical spring, A-39
      - internal tooth, A-40
    - plain
      - metric, A-36
      - type A, A-37
      - type B, A-38
- American National thread, 593
- American Society of Mechanical Engineers (ASME), 109, 111, 192, 193, 202-203
- AMF Bowling, 13
- Capital Equipment Division, 13
- organizational structure, 24-25
- product development process, 19-21
- Analogies, 70
- Analysis by solids, 386-387
- Analysis by surfaces, 388-389
- Anderson, Anna, 344, 446
- Andreasen, M. Myrup, 26
- Angle(s)
  - construction, 425-426, 445
  - location and orientation dimensions, 505
  - multiview representations, 370-371
  - oblique drawings and, 445
  - principal views and projection, 349-352
  - receding axis, 441
  - relative to a given line, 207-209
  - thread, 592
  - triangles and, 201, 208
  - units for, 501, 502
- Angular perspective, 450
- Angular units, 501, 502
- Angularity, 552, 553
- Apple Macintosh, 19
- Applications, 193
- Appropriate Technology 127
- ARC command, 218, 320-321
- Archimedes screw, 590
- Architect's scales, 210-211
- Archiving, 575
- Arcs, 218-219
  - of a circle, 330
  - irregular curves of, 333
  - isometric axonometric, 432
  - rectified, 333-334
  - sketching, 245-246, 264-265
- Area, limitations on, 508
- Arguments, 669
- Aristotle 133
- Arithmetic coordinates, 692
- Arithmetic operators, 664-665
- Arizona State University's Introduction to Engineering Design, 153
- Armstrong, Susan J. 140
- Arrow keys, 661
- Arrows, 503
- Arthur Morgan, Whistleblower 136-137
- Assembly, datum features and, 346
- Assembly drawings, 515, 578-582; *see also*
  - Assembly sections; Working drawings
  - isometric axonometric, 437-438
  - pictorial; *see* Pictorial drawings/sketches
  - Assembly sections, 478-480, 482; *see also*
    - Assembly drawings
    - thread drawings, 598
- Associative dimensioning, 541

Audio recording, 32  
 AutoCalculate feature, 672  
 Autodesk, Inc., 187, 195  
*Automobile Bumpers Mismatched*, 111  
 Automobile components imported 127  
 AutoSum, 666  
 Auxiliary sections, 452-483  
 Avallone, Eugene A., 79  
 Average of members' opinions, 155  
 Axis,  
   category, 687  
   isometric, 414  
   threaded fasteners and, 592  
   value, 687  
 Axonographs, 416  
 Axonometric axes, 414  
 Axonometric drawings/projections, 414-438  
   classifications of, 414  
   isometric, 414-438  
     construction and, 420-438  
       angles, 425-426  
       arcs, 432  
       assembly drawings, 437-438  
       boxing-in method, 419-423  
       circular features, 426, 427  
       curved intersections, 434, 435  
       ellipses, 426-432  
       four-center method, 429, 430  
       on inclined planes, 431-432  
       on oblique surfaces, 435  
       templates, 431  
       true, 426-428, 434  
   irregular curves, 426, 427  
   isometric grids, 242, 256-258, 438  
   nonisometric lines, 423  
   oblique planes, 424-425, 435  
   parametrics with, 433  
   screw threads/ fillets/rounds, 437  
   section views, 436-437  
   spheres, 435-436  
   hidden line standards, 418-419  
   line standards, 418-419  
   sketches, 250

## B

Baby-crib specifications 108  
 Babylon's building code 107-108  
 Backen, Arrigoni, and Ross Architects, 254  
 Bailen, Doug, 582  
 Balloon, 437, 585  
 Bar graph, creating, 62  
 Bar graphs, 687, 688  
 Baran, Michael S. 114, 115  
 Bargaining position of engineers 121  
 Baseline dimensioning, 505  
 Baseline project plan  
   contract book, 167-168  
   modifying, 170-171  
   project budget, 170  
   project risk areas, 170, 171  
   project schedule, 169-170  
   project task list, 168  
   team staffing/organization, 168-169  
 Basic dimension, 508  
 Basic hole system, 535-538  
 Basic shaft system, 538-539

Basic size, 524, 529, 535  
 Baumeister, Theodore, III, 79  
 Beam compass, 219  
 Beitz, Wolfgang, 79, 93  
 Belgard, William, 158, 161  
 Bellamy, Lynn, 152, 152, 161  
 Belliston, L., 294  
 Benchmarking, 18  
   for concept generation, 67-69  
 Benchmarking chart, 47-49  
 Benchmarking information, 47-49  
 Bennis, Warren, 148, 149  
 Benzon, W., 294  
 Bernard Gert 103  
 Best function, selection of (curvefitting), 723  
 Beta prototype, 16  
 Bhopal 128-132  
*Bhopal: Is Ignorance a Mitigating Factor?* 132  
*Bicycling* magazine, 46  
 Biederman, I., 294  
 Biederman, Patricia W., 148, 149  
 Bilateral tolerance, 524  
 Bill of materials (BOM), 52, 274-275, 575, 578, 584  
 Binding head fastener, 602  
 Binswanger, Hans Christoff 142  
 Biocentric Ethics, 141  
 Bird's eye view, 449  
 Bisector/bisection, 320  
 Blackstone, William T. 140  
 Blake, R. R., 156, 161  
 Blameworthiness 107  
 Blind holes, 373, 511, 572, 599, 600  
 BLOCK command, 221  
 Block of cells:  
   copying, 674  
   moving, 674-675  
   selecting, 671  
 Blueprints, 575; *see also* Working drawings, 132  
 Boeing Company code of cooperation, 152  
 Boffey, P.M. 103  
 Bok, Sisela 115  
 Bolt circles, 390  
 Bolts; *see also* Working drawings  
   metric hex, A-28  
   square head, A-19  
   standard, 600-601  
 Booker, P., 223, 447  
 Borders, 678  
 Bordewich, Fergus M. 132  
 Borrelli, Peter 102  
 Bottom view, 346  
 Botzler, Richard G. 140  
 Box, George E. P., 52, 57  
 Boxing-in method, 419-423, 442  
 Brassand, Michael, 148, 149  
 Break lines, 202-203  
 Breaks, section views and, 487-488  
 Bribes 116  
   *Lockheed Selling Airplanes* 132  
   *Purchasing Agent is Offered a Low Cost Vacation* 119  
 Bridges  
   Akashi Kaikyo 138  
   *Failures* 100  
   Yarrow Bridge, Melbourne, Australia 100

British standard dowel pins, A-45  
 Broken-out sections, 477  
 Brooks, Frederick, 463  
 Broome, Taft H. Jr. 103  
 Brown, S. M., 149  
 Browne, M. Neil, 146, 149  
 Browning, Tyson R., 165, 177  
 Brummett, Tim, 239  
 Bruno, Andrea 124  
 Budget allocations, 55-56  
 Budgets, 169-170  
 Buehler Products, Inc., 352  
 Buffer report, 175  
*Bumpers Do Not Match* 111  
 Burchill, Gary, 31, 38  
 Burlington Northern International  
   Transport Team, 147  
 Button, scroll, 658  
 Buttress threads, 592, 593

## C

Cabanis, Jeannette, 148-149  
 Cabinet oblique, 259, 439, 441  
 CAD, 189-190  
   applications  
     cutting plane lines, section views and, 472  
     databases, 190  
     sketching; *see* sketching *below*  
   databases and, 190  
   drawing tools, 194-197  
   lettering, 272-274  
   perspective drawings and, 451-453  
   sketching, 240, 242, 254  
   stereolithography and, 360  
   techniques  
     section views, 467-468, 472, 488  
     thread drawings, 600  
     threaded fasteners, 604  
   text and, 272-274  
   three-dimensional models and, 358-361; *see also* 3-D modeling/analysis  
   tolerances in, 540-541  
 CAD Technology Corp., 605  
 CADKEY, Inc., 489  
 Cahn, Steven M. 123  
 Calcomp, 195  
 Callicott, J. Baird 141  
 Cap screws, 602-603; *see also* American  
   National Standards Institute (ANSI)  
 CAPS, 658  
 Carrascosa, Maria, 177  
 Carter, Charles M. 119  
 Cartesian coordinates, 692  
 Case studies: conflict management, 161  
 Category Axis, 687  
 Caterpillar, Inc., 202  
 Cavalier oblique, 259, 439, 441  
 Cell address, 655  
   absolute, 676  
   relative, 676  
 Cell alignment, formatting, 678  
 Cell formulas, displaying, 682  
 Cell names, 666, 667  
 Cell patterns, 678  
 Cell reference, 655, 676  
 Cells, 656, 657

- active, 663
- clearing, 677
- copying, 672, 674
- inserting and deleting, 667-668
- moving, 674-675
- selecting, 671
- Center, of a circle, 330
- Center lines, 202-203, 265, 354, 355
- Central angle, 330
- Central view, 353
- Chain line, 202-203, 508-509
- Challenger* (Space Shuttle) 106, 112
- Chamfered pins, A-44
- Chamfers, 373-376, 377, 511, 592, A-44
- Change of planes (corners), 370
- Changes, undoing, 675
- Chart toolbar, 687
- Chart Wizard, 687
- Charter, 29
- Charts, 687
  - column, 687-688
  - line, 692
  - XY, 687, 688
- Cherbeneau, Jeanne, 148, 149
- Chew, W. Bruce, 57
- Chicago Bulls, 148
- Chord, of a circle, 330
- Chrysler Corp., 589
- CIRCLE command, 218, 320-321, 600
- Circles, 218-219
  - geometry, 330-332
    - center of, locating, 332
    - drawn through three points, 331
    - elements of, 330-331
    - templates, 331
  - oblique, 442
  - sketching, 245-246, 264-265
  - templates, 220-221
- Circular features, 426, 427, 442
- Circular line element, 549
- Circularity, of form, 550, 551
- Circumference, of a circle, 330
- Circumscribed circles, 331
- Civil engineering, 211-213
- Civil engineer's scales, 211-213
- Clarity, 508
- Clark, Kim B., 26, 167, 177
- Class 1 fit, 593
- Class 2 fit, 593
- Class 3 fit, 593
- Class FN 2, 539
- Class of fit, 593, 595
- Classifications
  - axonometric drawings, 414
  - perspective drawings, 450-451
- Classroom learning group, 146-147
- Clausing, Don, 44, 47, 57
- Clean Air Act 134
- Clear All, 664
- Clear Contents, 664
- Clearance fit, 525-526
  - locational (LC), 535, A-6
  - standard precision fits (English units), 535-538
  - using basic shaft system, 539
- Clevis pins, A-46
- Coarse series fasteners, 593
- Coaxial datum features, 557-558
- Code of Cooperation, 152-153
- Code of Hammurabi 107
- Codes of Ethics
  - As an Industrial Standard?* 112
- Column chart, 687, 688
  - creating, 689
- Column width, 664
  - adjusting, 667
- Columns, inserting and deleting, 676-677
- Combination scale, 209, 214
- Communication skills, 153
- Compac and Environment* 137
- Compass, 218-219, 320
- Competitive design, 85
- Competitive map, 54
- Compromise, 156
- Computer data exchange, 515
- Computer numeric control (CNC), 190
- Concatenation, 664-665
- Concentric circles, 331
- Concentricity, 554
- Concept classification tree, 62-63, 72-73
- Concept combination table, 62-63, 72-73
- Concept development, 16, 27-28
  - activities, 16-18
- Concept fragments, 70-72
- Concept generation, 17, 61-64
  - common dysfunctions, 62
  - evaluation of results, 77-78
  - external search, 66-67
  - five-step method, 62-64
  - hints for solutions, 70-71
  - internal search, 69-71
  - problem clarification, 64-66
  - systematic exploration, 70-78
- Concept scoring, 85-86, 87-91
  - combining and improving, 90-91
  - evaluating results, 91
  - preparing scoring matrix, 89-90
  - ranking concepts, 90
  - rating concepts, 90
  - selection of concept, 91
- Concept-scoring matrix, 95
- Concept screening, 85-86
  - combining and improving, 87-88
  - evaluation of results, 87-89
  - preparing selection matrix, 86-87
  - ranking concepts, 87
  - rating concepts, 87
  - selection of concept, 87
- Concept-screening matrix, 94
- Concept selection, 17
  - concept scoring, 88-91
  - concept screening, 86-89
  - criteria, 81
  - definition, 81
  - for industrial design, 70-71
  - methods, 83-84
  - overview of methodology, 85-86
  - in product development process, 81-83
  - six-step process, 86
  - structured process, 84-85
  - subtleties and cautions, 91-92
- Concept testing, 17
- Concurrent engineering, 189-190, 500, 589
- Cones; *see also* Conics/conic curves
  - multiview representations, 371-372
- Conflict of Interest: Electrical Engineering Prof.*, 118
- Conflicting interest, 116
- Confidentiality 113
  - avoiding breach of 115
  - imposed by employment contract 115
  - justification 115
  - management policies 115
  - used to hide misdeeds 116
  - when changing jobs 114
- Conflict definition, 156
  - steps in negotiating, 157
- Conflict management, 156-157
  - case, 161
- Conflict of interest 116
  - as FAA Inspector 118
  - expert witnesses 118
  - gifts, bribes, kickbacks 115
  - insider information 117
  - moonlighting 117
  - moral status 118
  - ties to other companies 117
- Conflict strategies, 156-157
- Confrontation, 156
  - guidelines for, 157
- Conics/conic curves, 334
  - ellipses; *see* Ellipses
  - hyperbolas; *see* Hyperbolas
  - parabolas; *see* Parabolas
- Conjoint analysis, 55-56
- Conscientious refusal, 120
- Conscientiousness and moral commitment, 104-105
- Consensus, 155
- Consent, informed, 101
- Consent, valid, 103
- Conservation, 140
- Constant pitch series fasteners, 593
- Constants, 662
- Construction, engineering; *see* Engineering geometry
- Construction lines, 247-250
- Consultant Pushes Parts Made by His Regular Employer*, 119
- Consulting on Radio Equipment*, 119
- Consumer Product Safety Commission (CPSC) 108
- Consumer Reports*, 46
- Contiguous areas, 389
- Contour dimensioning, 516
- Conventional breaks, 487-488
- Conventions, communications, 191-193
- Contract book, 17-18, 43, 167-168
- Control documentation, 16
- Cooper, Robin, 57
- Cooperative learning group, 146
- Coordinate dimensioning, 505
- Coordinate measuring machine (CMM), 8, 190
- Coordinate space; *see* Engineering geometry
- Coordinates, cartesian, 692
- Coordination, 14
  - of product and process, 85
  - mechanisms, 81-82

- COPY command, 600
- Copying:
  - a graph, 688
  - cells, 674
  - formulas, 675
- Coren, S., 294
- Corners, 370
- Correcting errors, 664
- Cost model, 52-53
- Cost-plus pricing, 58
- Costs
  - in concept selection, 91-92
  - of tolerance, 527
- Cotter pins, A-46
- Counterbored holes, 373-514
- Countersunk holes, 373, 514
- Coupled tasks, 162-164
  - in Gantt chart, 165-166
  - guidelines, 172-173
- Creating a bar graph, 689
- Creating a column chart, 689
- Creating a graph, 687-688
- Creating a log-log graph, 7012
- Creating a semi-log graph, 698
- Creating an x-y graph, 693
- Creative listening, 153
- Crest, 592
- Crib Dimensions*, 108
- Criteria, least squares, 707, 714, 715, 718, 720
- Critical chain method, 172
  - for assessing schedules, 175
- Critical listening, 153
- Critical path, 166-167
  - guidelines, 171-172
- Critical tasks, 166-167
  - focusing effort on, 176
  - overlapping, 172
- Cross-functional integration, 23
- Cross-hatch lines, 472-478
- Culver, Charles M., 103
- Curry, George E., 123
- Curve fitting:
  - exponential function, 715
  - logarithmic function, 716
  - multiple functions, 716
  - polynomials, 719
  - power function, 718
  - scaling data, 728
  - selecting the best function, 723
  - straight line, 705-707
  - variable substitution, 726-727
- Curved intersections, 434, 435
- Curved lines, 245-246, 320-321
- Curved surfaces, 371-372, 443-445
- Curves
  - irregular, isometric axonometric, 426, 427
- Customer attributes, 28
- Customer data template, 33-34
- Customer-focused product, 85
- Customer needs
  - in concept development, 27-28
  - and concept testing, 17
  - decomposition by, 66
  - identifying, 16-17
    - evaluating results, 37-38
  - goals in, 27
  - interpreting raw data, 27-34
    - need hierarchy, 34-36
    - raw data from customers, 29-34
    - by relative importance, 36-38
    - steps in, 28
  - and mission statement, 28-29
  - primary versus secondary, 35
  - and specifications, 42
- Customer needs data
  - art of eliciting, 31-32
  - means of gathering, 29-31
- Customer preferences, 54-55
- Customer requirements, 28
- Customers
  - documenting interactions with, 32-34
  - lead users, 30-32, 66-67
  - selected for interviews, 30-31
- Customer selection matrix, 31
- Customer statements, 33-34
- Customized products, 19-20
- Cutting-edge functional expertise, 23
- Cutting plane lines, 202-203, 471-472
- Cutting planes, 202-203, 281-284, 464, 469, 471-472
- Cylinder rule, 441
- Cylinders
  - intersecting other cylinders, 380
  - intersecting prisms and holes, 380
  - isometric pictorial sketching and, 255-256, 257
  - multiview representations, 371-372
- Cylindricity, of form, 550-552
- D**
- Dams
  - Aswan and Zambesi*, 142
  - Secondary Effects*, 142
- Data
  - exchange of, 515
  - items, formatting, 678
  - paired, 705
  - visualization; *see* Visualization
- Databases, 190
- Data-driven perspective, 164
- Data General Eclipse MV/8000, 113
- Dataquest, Inc., 184
- Data reference frames, 546-547
- Datum dimensioning, 505
- Datum feature identifiers, 547
- Datum features, 545-547
- Datums, 504, 505, 545-547
- Davie, Michael, 99
- Davis, Ruth M., 105
- Davis, Michael, 112, 116
- Day, George S., 57
- De George, Richard T., 132
- Decision by authority, 155
- Decision making methods, 155
  - in teams, 154-155
- Decision matrices, 85
- Decisions, effective, 155
- Decomposition
  - of concept quality, 91
  - functional, 64-66
  - problem, 64-66
- Decoupling tasks, 173
- Defensive engineering, 105
- Degrees of freedom, 546
- Delays
  - due to safety times, 172
  - due to waiting, 172
- Delehanty, Hugh, 148, 149
- Delete key, 664
- Deleting cells, 677-678
- Deleting rows and columns, 676-677
- Department of Defense (DOD), 192
- Dependent variables, 46
- Depth, 592
- Depth axis, 288-289
- Descriptive geometry, 364
- Design
  - agile, 435
  - of bolts, 600
  - CAD; *see* CAD
  - fasteners, head style, 602
  - GDT, 559-560
  - GDT applications, 559-560
  - global, 515
  - integrated; *see* 3-D modeling/analysis
  - problem solving visualization and, 276-278
  - process, 188-190
  - refinement and; *see* 3-D modeling/analysis
  - shipbuilding, 548
  - 3-D; *see* 3-D modeling/analysis
  - visualization; *see* Visualization
  - visualization for, 275-278
- Design brief, 29
- Design-build team, 22
- Design-of-experiments techniques, 52
- Design process, 188-190
- Design structure matrix, 164-165
  - example, 179-180
  - information transfers, 171
- DesJardins, Joseph R., 124, 140
- Detail design, 16
- Detail drawings, 575-578
- Detail numbers, 578
- Development, surface models, 285-287
- Deviation, 529
- Diameter, 330
  - dimensions, 504
  - vs. radius, detail dimensioning, 512
- Diameter symbol, 504
- Dies, threaded fasteners and, 592
- Dimension lines, 202-203, 503
- Dimensions, 499-522
  - assembly drawings and, 580
  - associative, tolerances in CAD and, 541
  - defined, 500, 501
  - detail, 510-516
    - blind holes, 511, 512
    - counterbored holes, 373, 514
    - countersinks, 514
    - diameter vs. radius, 512
    - grooves, 514
    - holes, 511, 512-514
      - counterbored, 373, 514
    - manufacturers' gages, 514-516
    - screw threads, 514
    - spotfaces, 514
    - standard sheet metal gage table, 516
  - symbols, 512

- functional, tolerancing and, 527-528
- geometric; *see* Geometric dimensioning and tolerancing (GDT)
- maximum material condition (MMC) and, 544-545
- single limit, 524
- size and location, 500-509
  - basic concepts, 504
  - coordinate dimensions, 505
  - extension lines
    - standard practices, 506-507
    - terminology, 508
  - orientation dimensions, 505
  - size, 504-505
    - diameter, 504
    - horizontal, 504
    - radius, 504
    - vertical, 504
  - standard practices, 505-509
    - area limitations, 508
    - extension lines, 507-508
    - grouping and staggering, 506-507
    - length limitations, 508
    - not to scale (NTS), 508, 509
    - out-of-scale dimensions, 508
    - placement, 505-506
    - reading direction, 508
    - repetitive features, 508
    - spacing, 506
    - staggering, 506-507
    - view dimensioning, 508, 509
- terminology, 501-504
  - arrows, 503
  - basic dimension, 503
  - datum, 504
  - diameter symbol, 504
  - dimension line, 503
  - extension line, 503
  - leader line, 503
  - limits of size, 503
  - plus and minus dimension, 503, 524
  - radius symbol, 504
  - reference dimension, 503
  - size, limits of, 504
  - tolerance, 504
  - visible gap, 503
  - units of measure, 500-501
- standards for, oblique drawing construction, 446
- techniques, 516-522
  - ANSI standards, 520-522
  - guidelines, 519-520
  - process for, 517-519
- unidirectional dimensioning, 508, 509
- Dimetric drawing/projection, 414
- Directrix, 334
- Disasters, 137
  - enabled natural disasters, 138
- Discrimination
  - based on race, 132
  - Discrimination Based on Age*, 122
  - Discrimination Based on Race*, 122
  - laws, 122-123
  - reverse discrimination, 123
- Display devices, 194-195
- Displaying cell formulas, 682
- Distance, object to picture plane, 451
- Distortions, perspective drawings and, 344
- Distributed actions approach, 151-152
- Diversity, 147-148
- DIVIDE command, 220
- Dividers, 219-220
- Division operator, 664
- Documentation, 189, 574
  - of decision process, 85
- Dolly (rivet tool), 606
- Donaldson, Thomas 192, 131
- Double-curved lines, 320
- Double-curved surfaces, 286
- Double thread fasteners, 593-594
- Dowel pins, 605, 606, A-45
- Drafting machines, 198, 202
- Drafting triangles, 201, 207-208
- Drawing number, 580
- Drawings, 186-188
  - assembly; *see* Assembly drawings
  - axonometric; *see* Axonometric drawings/projections
  - detail, 575-578
  - engineering, 185
  - isometric; *see* Isometric drawings/projections
  - multiview; *see* Multiview drawings
  - oblique; *see* Oblique drawings
  - paper for, 199-200
  - perspective; *see* Perspective drawings/projections
  - pictorial; *see* Pictorial drawings/sketches
  - pipng; *see* Piping drawings
  - production, 574
  - section assembly, 478-480, 482, 484, 580, 581
  - section line practices, 473, 475-476
  - sketches; *see* Sketches
  - subassembly, 575
  - technical; *see* Technical drawings/graphics
  - thread; *see* Threaded fasteners
  - two-point, 450
  - two-view, 265-266, 354, 356
  - working; *see* Working drawings
- Drilling, 510, A-26, A-27
- Drop-down menus, 656, 657
- Drug Testing on Job, 123
- Duska, Ronald 165 (f18)
- Dual dimensioning, 501, 502
- DuPont, 360
- Dürer, Albrecht, 446, 447
- Duty
  - negative duties, 104
- Dye-sublimation printers, 197
- E**
- Earthquakes*, 138
  - 1989 Loma Prieta, CA
  - 1994 Northridge, CA
  - 1995 Kobe (Hanshin), Japan
  - 1999 Izmit & NW Turkey
- Easterling, Mahlon, 103
- Eastman Kodak Cheetah microfilm cartridge, 163-, 165, 168-171, 173, 174, 176
- Eccentric circles, 331
- Eclipse Computer (Data General)*, 113
- Ecocentric ethics, 141
- Economic analysis
  - by project team, 18
  - what-if analysis, 52
- Eder, W. Ernst, 79
- Edges/Edge views, 278
  - on multiview drawings, 364-368
  - of normal face, 291
  - orthographic projection and, 368
  - section views and, 469
- Editing a worksheet, 671
- Editing shortcuts, 679
- Electrical circuits, 668, 669
- Edwards, B., 294
- Effective teams, 145-146
  - characteristics, 148
- Einstein, Albert, 275
- Ellipses
  - axonometric, 426-432
  - elliptical surfaces and, 373, 379, 435
  - isometric, 426-429
  - multiview representations, 372
  - oblique, alternate-four-center-method, 442-443, 444
  - sketching, 246, 254-255
- Employee rights, 121
- End key, 662
- Engelbart, Doug, 464
- Engineer's work, meeting moral obligations, 104-105
  - need of foresight, 104
- Engineering
  - as social experiment, 99, 101
  - learning from mistakes, 100
  - monitoring, 100
  - uncertainty, 100
- Engineering
  - design process, traditional, 188
  - drawings, 185
  - by major activities, 184
- Engineering geometry
  - angles, 425-426, 445
  - arcs; *see* Arcs
  - circles; *see* Circles
  - conic curves, 334
  - ellipses; *see* Ellipses
  - hyperbolas; *see* Hyperbolas
  - parabolas; *see* Parabolas
  - geometric elements, 317
  - lines; *see* Line(s)
  - octagons; *see* Octagons
  - ogee curves, 333
  - points, 317
  - roulettes; *see* Roulettes
  - ruled surfaces; *see* Surfaces
  - tangencies; *see* Tangent/Tangencies
- Engineers, 186
- Engineers' work, wider context, 104
- English system, thread specifications, 592-595
- Enter key, 663, 664
- Entering and leaving Excel, 655
- Entering data, 662
- Envelope principle, 545
- Environment
  - disposal costs, 139
  - personal commitment, 139
  - environmental costs internalized, 139



- Environmental ethics  
 biocentric, 141  
 ecocentric, 141  
 human centered, 140  
 Native American tribes, 141  
 nature-centered, 140  
 sentient-centered, 140  
 virtue ethics, 141
- Environmental leadership, 137
- Environmental Topics, 142
- Environmental Protection Agency (EPA), 134
- Eppinger, Steven D., 164, 165, 177
- Equal opportunity, 122
- Equation:  
 exponential, 697-698  
 power, 700
- Erasers/erasing, 205, 206, 241
- Erasing shield, 205, 206
- Error, data point, 705
- Errors, correcting, 664
- Ethical  
 absolutism, 131  
 pluralism, 131  
 relationalism, 131  
 relativism, 131
- Ethics codes, see engineering societies  
 by name
- Everest, Larry, 128
- Everglades Lack Water*, 136
- Ewing, David W., 121
- Excel:  
 entering and leaving, 655  
 help, 658, 659  
 leaving, 655-657, 659  
 Office Assistant, 18  
 What's This?, 18
- Exiting Excel, 655-657, 659
- Experiment  
 control, 101  
 human subjects, 101  
 informed consent, 101, 104  
 unexpected outcomes, 103
- Expert member, 155
- Exponential equation, 687
- Exponentiation operator, 664-665
- Experts, 67
- Exporting Hazardous Technology (Bhopal)*, 132
- EXT, 658
- Extension lines, 202-203, 503, 506-507
- External decision, 83
- External search  
 by benchmarking, 67-69  
 consulting experts, 67  
 interviewing lead users, 66-67  
 in patents, 67-68  
 in published literature, 68  
 purpose, 66
- External thread, 592
- External tooth lock washers, A-40
- Extortion, 116
- Extra fine series fasteners, 593
- Exxon Valdez Oil Spill*, 142
- Eye level, 447
- F**
- Faces, 278
- Face-to-face rule, 279
- Family of parts, 589
- Farm Machinery & Labor*, 104
- Fastening, 589
- Feature control frame, 542
- Feature(s)  
 circular, 426, 427, 442  
 control, 546  
 hidden, 464-467  
 repetitive, 508  
 thin, 585-486
- Fedo, David A., 132
- Feeder buffers, 172, 175
- Ferguson, E.S., 223
- Fiat Auto, 180
- Field rivets, 606, 607
- Filletts, 373-376, 437
- Fillister head fastener, 602
- Final specifications, 43; *see also* Target specifications  
 cost model, 52-53  
 evaluating, 56  
 flow down, 55-56  
 refining, 53-55  
 steps, 51  
 target costing, 58-59  
 technical models, 51-52
- Financial arrangements, 21
- Fine series fasteners, 593
- Finished bolts, 601
- Finished surfaces, 373-376
- Finish marks, 373-376
- Firms  
 organizational structure, 23-25  
 product-based, 21-24
- First-angle projection, 349-352
- Fisher, Kimball, 158, 161
- Fits; *see also* American National Standards Institute (ANSI)  
 classes of, 535-540, 593, 595  
 clearance, standard, 535-538  
 clearance locational (LC), A-6  
 determining, 527  
 metric, preferred, A-10  
 standard precision, 534-540  
 tolerance and, 525-527  
 transition, A-7
- Fitting multiple functions to a data set, 726
- Fixed fastener tolerancing, 558
- Flat head fastener, 602; *see also* American National Standards Institute (ANSI)
- Flat head machine screws, A-24
- Flatness, of form, 550, 551
- Floating fasteners, 558
- Flow chart, 277
- Flow down, 55-56
- Focus groups, 30
- Fold lines, 346-348
- Fontenelle Dam, 104
- Fonts, 271, 678  
 lettering; *see* Lettering  
 sketching and; *see* Sketches
- Force, spring, 696, 703
- Force and shrink fits (FN), 535, A-9
- Forcing, 156
- Ford, Henry, 145
- Ford Motor Company code of cooperation, 152-153
- Foreign Corrupt Practices Act, 133
- Foreshortened plane, 368
- Foreshortening, 364
- Form controls, GDT; *see* Geometric dimensioning and tolerancing (GDT)
- Formatting:  
 cell alignment, 678  
 data items, 678
- Form-only models, 18
- Formula bar, 656, 657, 663, 664
- Formulas, 664  
 copying, 4  
 displaying, 682  
 moving, 675, 676
- Front-end process, 16
- Foster, Robert, 316, 497
- Foster, Sallie, 152, 153, 161
- Four-center ellipse method, 429-430
- Freedom Space Station*, 515
- Freehand drawing (sketch); *see* Sketches
- Free state, 521-522
- French, Thomas E., 316, 420, 497
- French curves, 208-209
- Friedhoff, R.M., 294
- Frontal image plane, 290
- Frontal plane, 341, 342, 365
- Front view, 260, 343, 345
- Full section, 476
- Functional decomposition, 64-66
- Functional dimensioning, 527-528
- Functional organizations  
 characteristics, 22  
 merits of, 23-24
- Function diagram, 65-64
- Functions, 21, 669  
 commonly used, 670
- Fundamental deviation, 529
- Futernick, Jennifer, 146
- G**
- Gaging tolerance, 548
- Galbraith, Jay R., 26
- Gallery method, 70  
 Gantt charts, 165-166, 174  
 Generic development process, 14-17  
 customized products, 19-20  
 phases, 14-17  
 platform products, 19  
 process-intensive products, 19  
 technology-push products, 18-19
- Gas, ideal, 668
- Gas constant, ideal, 668
- Gas law, ideal, 696
- General oblique, 439
- General purpose section line, 472-473
- General tolerance notes, 586
- Geometric accuracy, 541
- Geometric breakdown dimensioning, 516
- Geometric dimensioning and tolerancing (GDT), 541-544  
 design applications, 559-560  
 fixed fasteners, 558

- floating fasteners, 558
- geometric controls, 548-558
  - axis straightness, 549
  - for form, 549-552
  - for inspection processes, 548
  - line element straightness, 549
  - for location, 554-558
  - for orientation, 552-554
  - perfection, 548
  - tolerance zones, 529, 532, 548
  - virtual condition, 548-549
- hole diameter tolerancing, 559
- maximum material condition (MMC), 525
- rules, 542-544
- symbols, 542
- tolerance calculations, 558-559
- Geometric elements, 317
- Geometric forms, standard, 382
- Geometric modeling, 190
- Geometric primitives, 369
- Geometrics, 500
- Geometry, engineering; *see* Engineering geometry
- Geometry files, 540
- Gershenfeld, Matti K., 152, 161
- Getting help, 16, 658, 659
- Gib head keys, 606, A-43
- Gifts and gratuities, 116-117
- Global design, 575
- Global issues, 127
- global marketplace, 127-128
- Goethe, Johann Wolfgang, 142
- Goldberg, David E., 158, 161
- Goldenberg, Jacob, 79-80
- Goldratt, Eliyahu M., 172, 178
- Goodrich and Donald Wohlgemut*, 114
- Goldstein, E.B., 294
- Gordon, S.F., 294
- Gore-Tex, 18
- GoTo key, 662
- GPA, student, 667, 681
- Grade point average, 667, 681
- Grades, 200, 595
- Graham, Alan, 39
- Graph:
  - copying, 688
  - creating, 687-688
  - moving, 688
- Graphics theory, 193
- Graphs:
  - bar, 687-688
  - log-log, 700
  - semi-log, 697
  - x-y, 59, 687, 692
- Gratuities: ASCE and ASME guidelines, 117
- Graves, F.E., 609
- Green, Don W., 79
- Green, N., 596
- Greenhouse effect, 134
- Grids/Grid papers, 242, 256-258
- Griffin, Abbie, 29, 33, 38
- Grooves, detail dimensioning, 514
- Ground line, 449, 451
- Ground's eye view, 449-450
- Group accountability, 148
- Group decision making, 143
- Group maintenance roles, 152
- Group norms, 152
- Group performance, 146
- Group processing, 148
- Group task roles, 152
- Group-think, 137
- Groups compared to teams, 147
- Grouping and staggering, 506-507
- Guidelines, 219, 519-520
- Gunn, Aalstair S., 140
- Gutenberg, Johann, 268
- H**
- Haase, B., 589
- Hackman, J. R., 148, 149, 158, 161
- Half sections, 476-477
- Hall, Elaine M., 178
- Hammurabi, 107-108
- Hand/eye/mind connection, 277
- Hand lettering, 269-271
- Hanks, K., 294
- Hardin, Garrett, 133, 142
- Hardware, 194
- Hargrove, Robert, 148, 149
- Hatley, Derek J., 57
- Hauser, John R., 29, 30, 33, 38, 39, 44, 47, 57, 90, 93
- Haydon, Graham, 104
- Hayes, Robert H., 22, 23, 26
- Hays, C. V., 93
- Head style design, fasteners, 602
- Heavy hex nuts, A-22
- Heavyweight project organization, 22-23
- Hein, Lars, 26
- Helical spring lock washers, A-39
- Helixes, 590
- Heller, Peter B., 127, 128
- Helms, M., 454
- Help, 658, 659
- Hewlett-Packard Co., 15Hexagon and spline
  - socket set screws, A-32, A-33
- Hexagon machine screw nuts, A-24
- Hexagon socket head cap screws, A-26
- Hexagon socket head shoulder screws, A-27
- Hex and hex flange head metric machine
  - screws, A-30
- Hex cap screws, A-17
- Hex head bolts, ANSI standards, A-28
- Hex head fastener, 602
- Hex jam nuts, A-20
- Hex nuts, A-20
- Hidden features, section views and, 464-467
- Hidden lines, 202-203, 353-354
  - assembly drawings and, 580
  - section views and, 464-467, 468, 469
  - standards for, isometric axonometric
    - drawings, 418-419
- Higbee, F.G., 223
- High-performance cooperative learning group,
  - 146-147
- High-performing teams, 146
- Hill, Edward, 183
- Hill, Thomas E., 140
- Hiring Away Engineers who Know Trade Secrets*, 119
- Hoepner, Ken, 146-147
- Hoffman, W. Michael, 132
- Hole basis, 532
- Holes
  - column values, 539
  - cylinders intersecting, 380
  - detail dimensioning, 511, 512-514
    - counterbored, 373, 514
  - diameter tolerancing, 559
  - hole basis limits and fits, 532-534
  - location from edges, 556
  - location from hole, 556-557
  - multiview representations, 373-373, 374
  - standard system for, 535-538
- Home key, 662
- Horizon line, 447
- Horizontal axis, 288-289
- Horizontal dimensions, 504
- Horizontal image plane, 290
- Horizontal lines, 204
- Horizontal plane, 365
- Horizontal plane of projection, 342
- Horizontal position, 505
- Horizontal section view, 492
- Horton, H.L., 609
- House of Quality, 44, 48
- Howlett, Eric, 81
- Hubka, Vladimir, 79
- Hughson, Roy V., 119
- Human-centered Ethics, 140
- Human's eye view, 449
- Hunter, J. Stuart, 57
- Hunter, William G., 57
- Hydrolevel and ASME, 109, 111
- I**
- I Only Work Here*, 111
- Icon, 655
- Ideal gas, 668
- Ideal gas law, 696
- Ideal value, 47
- Ideation, 188, 278
- If I Don't, Someone Else Will . . .*, 111
- Iijima, Nobuko, 136
- Image planes, 287-292
- Implementation, design; *see* 3-D
  - modeling/analysis
- Imported automobile components, 127
- Incentives, 174
- Inches, 501-502
- Inclined edges/lines/planes, 205, 282, 291, 364, 366, 431-432
- Inclined face projection, 291
- Independent variables, 46
- Individual accountability, 148
- Individual feature of size, 542-544
- Informal communication, 174
- Information: privileged, secret, confidential,
  - proprietary, etc., 113
- Information facilitating exchange of, 171
- Information processing view, 164
- Information systems, 174, 175
- Inkjet printers, 197
- Input devices, 195-197
- Inscribed circles, 331
- Inserting cells, 677-678
- Inserting rows and columns, 676-677

compound, 688  
 Integrated project team, 22  
 Interchangeable parts, 522-523  
 Interference fits, 526, 527, 535, 538, A-8  
 Intergraph Corp., 345  
 Intermediate technology, 128  
 Internal search  
   guidelines, 69  
   hints for solutions, 70-71  
   individual and group sessions, 69-70  
   Internet search, 67-68  
   Interviews, 30  
   selection of customers, 30-31  
 Internal thread, 592, 599, 600  
 Internal tooth lock washers, A-40  
 International Standards Organization (ISO),  
   192, 215, 529-534  
 International System of Units (SI), 215, 500  
 International tolerance grade (IT), 532  
 Intersecting lines, 318  
 Internalizing environmental costs, 139  
 International marketplace, 127  
 International rights, 131  
 Intersection ( $\propto$ ), 318  
 Introduction to Engineering Design, 153  
 Intuition, 83  
 Irregular curves, 321, 379  
   of arcs, 333  
   isometric axonometric drawings with, 426,  
     427  
   line drawing, 208, 209  
 Isometric axes, 251, 414-416  
 Isometric drawings/projections, 250, 414  
   axonometric; *see* Axonometric  
     drawings/projections  
   pictorial sketches, 251-256  
 Isometric ellipses, 254-255  
 Isometric grids, 242, 256-258, 438  
 Isometric lines/planes, 414, 419  
 Iterations  
   decoupling tasks to avoid, 173

## J

Jackson, Phil, 148, 149,  
 Jansen, Robert B., 104  
 Japanese Standards (JIS), 192  
 Johnson, David W., 148, 149, 155, 161  
 Johnson, Frank P., 148, 149, 155, 161  
 Johnson, Roger T., 148, 149, 155, 159, 161  
 Joiner, Brian L., 148, 149, 156, 158, 161  
 Joining, 590-591  
 Jones, F.D., 609  
 Jones, Hardy, 112  
 Jordan, Michael, 148  
 Josephson, Michael, 120

## K

Kanemi Rice Oil, 135  
 Kariba Dam (Zambesi), 142  
 Kates, Robert, 108  
 Katzenbach, Jon R., 146, 147, 148, 149, 158,  
   161  
 Keeley, Stuart, 146, 149  
 Keeney, Ralph G., 93  
 Kennametal, Inc., 482, 587

Kepner, Charles H., 93  
 Kerzner, H., 177  
 Keys; *see also* American National Standards  
   Institute (ANSI)  
   as nonthreaded fasteners, 606-607  
   size of vs. shaft diameter, A-43  
 Keyseats, 606  
   dimension for Woodruff keys, A-41  
 Keyways, dimensioning, 511  
 Kinnear, Thomas C., 38-39  
 kickbacks, 116  
 Kidder, Tracy, 113  
 Klein, Burton H., 103  
 Knowlton, K.W., 294  
 Knuckle threads, 592, 593  
 Kohn, Philip M., 119  
 Kostner, Jaclyn, 178  
 Kotchian, Carl (Lockheed president), 132  
 Kouzes, J. M., 153-154, 161  
 Krishnan, Viswanathan, 172, 178  
 Kumar, V., 57

## L

Label, 655, 663  
 Lachs, John, 106  
 Lake Okeechobee, 136  
 Land, M.H., 223  
*Land Reclamation by Goethe's Faust*, 142  
 Lange, Ann E., 132  
 Lathe, Benefits from Quieter Operation, 139  
 Lauter, Carl E., 467  
 Law, balanced outlook, 107  
 Laws, lagging technological change, 108  
 Laws, minimal compliance, 107  
 Lead users, 30-31, 66-67  
 Leader lines, 503  
*Leader's Handbook* (Scholtes), 154  
 Leadership  
   behavioral commitment, 154  
   characteristics, 153-154  
   competencies of, 154  
   distributed actions approach, 151-152  
 Leads, 490, 492  
 Learning teams, 146-147  
 Least material condition (LMC), 525, 544  
 Least squares criteria, 707, 714, 715, 718, 720  
 Least squares curve fitting in Excel, 708  
 Least squares equations, derivation of, 714  
 Least squares, method of, 705  
 Leaving Excel, 656, 659  
 Left-hand threads, 594  
 Left side views, 346  
 Leifer, Larry, 149  
 Length, 508  
 Leonardo da Vinci, 191, 223, 275, 276, 446, 447  
 Leopold, Aldo, 141  
 Lettering, 268-274  
   alternate text styles, 271-272  
   CAD technique, 272-274  
   by hand, 269-271  
   standards, 268-269  
 Lettering guides, 269  
 Lettering templates, 268-269  
 Leventon, W., 284  
 Levy, Matthys, 104  
 Life cycle cost and strategy, 137

Light Bulb Sockets, 110  
 Lloyd, William Foster, 133  
 Lightweight project organization, 22-23  
   at AMF, 25  
 Limit form, of metric tolerancing, 534, 535  
 Limiting element, 278  
 Limits, 524  
 Limits of size, 503  
 Line charts, 692  
 LINE command, 330, 472, 600  
 Line element, 549  
 Line of sight (LOS), 339  
 Line profile, 552-553  
 Line(s), *see also* Edges/Edge views  
   alphabet of, 202-204, 353  
   conventions, 264, 353-358  
   cross-hatch, 473-476  
   curved, 208-209, 245-246, 320-321  
   dimension, 503  
   French curves, 208-209  
   geometry  
     curved, 208-209, 245-246, 320-321  
     straight, 243-244, 318-320  
   ground, 339, 451  
   hidden isometric, 418-419  
   horizon, 447  
   inclined, 364  
   irregular curves, 208-209  
   isometric standards, 418-419  
   miter, 268  
   nonisometric, 252, 418, 423  
   normal, 364  
   oblique, 364  
   parallel, 206  
   precedence of, 264  
   straight, 243-244, 318-320  
   tangencies and; *see* Tangent/Tangencies  
   true-length, 364  
 Line weight, 17  
 Listening techniques, 153  
 LMC; *see* Least material condition  
   (LMC)  
 Loaded salary rates, 169-170  
 Location  
   geometric controls for, 554-558  
   size and; *see* Dimensions  
 Locational fits  
   (LC), 535, A-6  
   (LN), A-7, A-8  
*Lockheed Bribes Overseas*, 132  
 Locking devices, 604  
   washers, 605, A-40  
 Locus, 317  
 Logitech, 195  
 Log-log graphs, 700  
 Long axis isometric, 418  
 Long dimension orientation, 441  
 Lopez, Jose Ignacio, 114  
 Lopez and GM vs VW, 114  
 Lord, Walter, 99  
 LOS, 339  
 Lower deviation, 529  
 Lower limit, 522  
 Lowrance, William W., 108  
 Lugs, 485-486, 487



**M**

McCullough, M., 294  
 McGill, Andrew R., 137  
 McGrath, Joseph E., 69, 79  
 McKim, Robert H., 70, 79, 294  
 McKim, R.H., 294  
 McKinsey & Company, 146  
 McLuhan, Marshall, 142  
 McNeill, Barry, 152, 153, 161  
 Machine, 608  
 Machine screws, 600, 603  
   flat head, A-24  
   hex and hex flange head metric, A-30  
   slotted flat head metric, A-31  
 MacKinnon, Catherine A., 123  
 Maier, Mark W., 57  
 Maintenance roles, 152  
 Majority control, 155  
 Management behavior change, 152  
 Managing diversity, 147  
*Mastering the Art of Creative Collaboration*  
   (Hargrove), 148  
 Major arc, 330  
 Major diameter, 592-594  
 Maloney, James O., 79  
 Management, 14  
 Manufacturers' gages, 414-416  
 Marginally acceptable value, 47  
 Margins, 58-59  
 Market Mechanism, 139  
 Marketplace comparisons, 46  
 Market-pull situation, 18, 19  
 Marks, 373-376  
*Mark's Standard Handbook of Mechanical Engineering*, 67  
 Markus, M. Lynne, 178  
 Martin, L.C., 294  
 Massachusetts Institute of Technology, 165  
 Material symbols, 472-473  
 Matrix organization  
   at AMF, 24  
   characteristics, 22-23  
   merits of, 23-24  
 Maus, K., 451  
 Maximum material condition (MMC), 525, 544-545  
 Mazursky, David, 79  
 Mechanical engineering, scales for, 213-215  
 Mechanical fastening, 589  
 Mechanical pencils, 199  
 Mechanisms, working drawings; *see* Working drawings  
*Mechanisms and Mechanical Devices Sourcebook*, 67  
 Media, 199-200  
 Meetings, 174  
   timing or frequency of, 175  
 Melman, Seymour, 139  
 Menu bar, 656-657  
 Menus, drop-down, 655, 656  
 Method of least squares, 705  
 Metric equivalents, A-3  
 Metric fits, preferred, 532-534, A-10, A-13  
 Metric scales, 215-218  
 Metric system, threaded fastener specifications, 595-597

Metric thread, 592, 593  
 Metrics  
   list of, 43-48  
   values of, 47-48  
 Midgley, Mary, 141  
 Midpoint, 310  
 Milgram, Stanley, 107  
 Millimeters, 500-502  
*Minamata Disease*, 135  
 Minor arc, 330  
 Minor diameter, 592  
 Minority control, 155  
 Mironi, Mordechai, 122  
 Mission statement, 28, 29  
 Missing lines, 385-386  
 Mitchell, W.J., 294  
 Miter line, 268  
 MMC, 525, 544-545  
 Mock, Cindee, 124  
 Modeling, 381-383; *see also* 3-D modeling/analysis  
   geometric, 190  
 Mohler, James, 582  
 Monge, Gaspard, 223  
 Moral (see also ethical)  
   accountability, problems with, 107  
   accountability, 106  
   autonomy, 105  
 Morgan, Arthur, 137  
*Mountain Bike* magazine, 44, 46  
 Mountain bikes, 484  
 Mouse, 195  
 Mouse pointer, 661  
 Mouton, J. S., 156, 161  
 Moving:  
   a graph, 688  
   cells, 674-675  
   formulas, 675-676  
 Multinational corporations, 127  
 Multiple functions, fitting to a data set, 726  
 Multiple image planes, 289-292  
 Multiple sectioned views, cutting plane lines and, 473  
 Multiple thread specifications, 593-594  
 Multiplication operator, 664-665  
 Multiview drawings, 187, 250, 337, 412  
   advantages of, 343-345  
   ANSI standards for, 389-391  
   edges and planes, 364-368  
   one-view, 265  
   principal views, 261, 263, 290-292, 345-361  
     adjacent views, 349-350  
     arrangement, standard, 350  
     bottom, 346  
     first- and third-angle projection, 349-352  
     fold lines, 346-348  
     front, 260, 343, 345  
     left side, 346  
     line conventions, 353-358  
     one- and two-view drawings, 354, 356  
     placement, conventional, 348  
     rear, 346  
     related views, 352  
     right side, 345-346  
     from 3-D CAD models, 358-361  
     three-view drawings, 354-358

top, 342, 343, 345  
 projection planes, 341, 343  
 projections and, 259, 263, 337-343  
   line of sight (LOS), 339  
   parallel vs. perspective, 341  
   plane of projection, 340  
 representations, 368-381  
   angles, 370-371  
   changes of planes (corners), 370  
   curved surfaces, 371-372  
   cylinders, 380  
   elliptical surfaces, 373, 377  
   fillets, rounds, and chamfers, 373-376, 377  
   holes, 372-373, 374  
   intersecting cylinders, 380  
   irregular or space curves, 379  
   planes, 368-370  
   points, 368  
   runouts, 376-378  
 sketches; *see* Sketches  
 of solid primitive shapes, 369  
 technique, 262-265  
   circles and arcs, 264-265  
   lines, precedence of, 264  
 three-view, 266-268  
 two-view, 265-266  
   view selection, 361-364  
   visualization; *see* Visualization  
 Multiview projection, 341-343  
 Multivoting, 83, 86

**N**

Nader, Ralph, 133  
 Name box, 657  
 Naming cells, 666, 667  
 Napier, Rodney W., 152, 161  
 National Fire Protection Association (NFPA), 110  
 National Electrical Code (NEC), 110  
 National Society of Professional Engineers (NSPE)  
   *Opinions of the Board on several cases*  
     75-10: Consulting on Radio Equipment, 119  
 Natural disasters, 137  
 Natural resources, 133  
 Nature-centered Ethics, 140  
 Navier, Louis Marie Henri, 100  
 Need hierarchy, 34-36  
 Needs, 27  
 Needs-metric matrix, 44-46  
 Need statement, 34-36  
 Negative solids, 279-281  
 Nigeria: Oil Drilling Damage, 1133  
 Node, 317  
 Nominal size, 524, 539  
 Nominal size range, 539  
 Nonisometric lines/planes, 252, 418, 423  
 Nonisometric planes, 418  
 Nonparallel line, 318  
 Nonverbal information, 32  
 Normal face, 282  
 Normal face projection, 290  
 Normal lines, 364  
 Normal plane, 365  
 Norman, Donald A., 38

Northrop Grumman Corp., 185, 187, 189  
 Norton, Bryan G., 142  
 Note form, of metric tolerancing, 534, 535  
 Notes, 534, 535, 586  
   thread specifications, 594-587  
 Note-taking, 32  
 Not to scale (NTS), 508, 509  
 Novitski, B.J., 254  
 NUM, 658  
 Number of threads per inch, 594  
 Numbers, 655, 662  
   formatting, 678  
 Numerical constant, spreadsheet, 655, 662  
 Numerical values, 662  
 Nuts  
   heavy hex, A-22  
   hex, A-20  
   hex flange, A-23  
   hex jam, A-20  
   hex machine screw, A-24  
   metric hex, styles 1 and 2, A-22  
   metric hex jam, A-22  
   metric slotted hex, A-23  
   square, A-21  
   square machine screw, A-24  
   standard, 587

**O**  
 Oberg, E., 609  
 Object-image plane orientation, 288-289  
 Object orientation rules, oblique drawings, 439-441  
 Oblique drawings, 413-414, 438-446  
   classifications of, 439  
   construction, 441-446  
     angles, 445  
     box technique, 442  
     curved surfaces, 443-445  
     dimensions, standards for, 446  
     ellipses, 444  
     oblique sections, 445  
     screw threads, 445-446  
   curved surfaces, 443-445  
   object orientation rules, 439-441  
   perspective; *see* Perspective drawings/projections  
   projection theory, 439  
 Oblique face, 282  
 Oblique face projection, 292  
 Oblique lines, 364  
 Oblique objects  
   drawings; *see* Oblique drawings  
   lines, 364  
   planes, isometric axonometric, 424-425  
 Oblique pictorials, 258-259  
 Oblique planes, 366  
 Oblique projection, 439  
 Oblique projection, sketches, 250  
 Oblique section views, 445  
 Office Assistant, 658  
 Offset coordinate method, 443-445  
 Offset measurement, 423  
 Offset section, 478  
 Ogee curves, 333  
 One-point perspective drawings, 450  
 One-view drawings/sketches, 265, 354, 356

Operator precedences, 665  
 Operator, string, 664-665  
 Operators, 664-665  
   arithmetic, 664  
   comparison, 665  
 Ordinate, 687  
 Origin, point, 505  
 Orthographic projection  
   multiview drawings, 341  
   principles of  
   rule 1, alignment of features, 349-352  
   rule 2, distances in related views, 353  
   rule 3, true length and size, 364  
   rule 4, foreshortening, 364  
   rule 5, configuration of planes, 368, 370  
   rule 6, parallel features, 368  
   rule 7, edge views, 368  
   rule 8, contiguous areas, 389  
 Organizational structure  
   at AMF, 24  
   merits of options, 24  
 Organizing Genius (Bennet & Biederman), 148  
 Orthogonal planes, 349  
 Otto, Kevin N., 93  
 Outline assembly, drawings, 580  
 Outline sections, section line practices, 474  
 Out-of-scale dimensions, standard practices, 508  
 Output devices, 198  
   dye-sublimation printers, 197  
   inkjet printers, 197  
   pen plotters, 197  
 Outside resources, 176  
 Outsourcing, 172  
 Over-dimensioning, 519  
 Overlapping tasks, 172  
 Ozone, protective layer, 134-135

## P

Page, Walter P., 134-135  
 PageDown key, 661  
 PageUp key, 661  
 Pahl, Gerhard, 79  
 Paired data, 705  
 Pan head fastener, 602  
 Pancari, A.J., 609  
 Paper  
   drawing, 199-200  
   for sketching, 241-242  
 PARABOLA command, 335  
 Parabolas, 334  
   construction of, 334-337  
   parallelogram method, 334, 335  
   engineering applications of, 334-335  
 Paraboloids, 335  
 PARALLEL command, 206, 600  
 Parallel edge, 198  
 Parallel features, orthographic projection and, 368  
 Parallelism, orientation, 552  
 Parallel lines, 318-319  
   line drawing, 206  
 Parallelogram method, 335, 336  
 Parallel perspective, 450  
 Parallel projection, 250  
   vs. perspective, 341  
 Parallel steel dowel pins, A-45  
 Parallel tasks, 163-164  
   in Gantt chart, 164-166  
 Parametric(s), 433  
   agile manufacturing, isometric axonometric, 433  
 Partial views  
   ANSI standards for, 389-390  
 Part number, 580  
 Part(s)  
   bill of materials; *see* Bill of materials (BOM)  
   identification/numbers, working drawings and, 580, 584-585  
   lists, working drawings and, 584-585  
*Part-time Lecturers Teaching Several Places*, 120  
 Partial knowledge, 99  
 Partitioning design structure matrix, 165  
 Paste function, 669  
 Patent notation, 110  
 Patent searches, 67-68  
 Patents 113  
 PATTERN command, 221  
 Patterns, cell, 678  
 Payne, Stanley L., 38  
 Pellegato, Thomas J., 360  
 PCB, 135, 136  
 Pencils, 199, 200  
 Pen plotters, 197  
 Percentage operator, 664  
 Perfect form at MMC, 544-545  
 Perfection, 548  
 Periodic action principle, 70  
 PERPENDICULAR command, 207  
 Perpendicularity, orientation, 553  
 Perpendicular lines, 318  
   drawing, 206-207  
 Perspective drawings/projections, 250, 446-453  
   CAD, 451-453  
   classifications of, 450-451  
   dimensional distortion and, 344  
   parallel vs., 341  
   sketches, 250  
   variables selection, 451  
 Perry, Robert H., 79  
*Perry's Chemical Engineers' Handbook*, 67  
 PERT charts, 165-167, 174  
 Peter Paul Electronics Co. Inc., 360  
 Phantom lines, 202-203  
 Phadke, Madhav S., 52, 57  
 Physical models, construction of, visualization and, 381-383  
 Physicians for Social Responsibility, 134  
 Photographs, 32-33  
 Physical layout, 21  
 Pictorial assembly, 580  
 Pictorial drawings/sketches, 239, 250, 413-462  
   for assembly, 580, 582, 583  
   axonometric; *see* Axonometric drawings/projections  
   oblique; *see* Oblique drawings  
 Picture plane, 447, 451  
 Piece tolerance, 525  
 Pierce, Christine, 140  
 Pins

- British standard parallel steel dowel, metric series, A-45
- chamfered, A-44
- clevis, A-46
- cotter, A-46
- as nonthreaded fasteners, 605-606
- square end, A-44
- taper, A-44
- Pipe threads, thread drawings, 598-600
- Pipelining, 172
- Pippin, Scottie, 148
- Pitch
  - diameter, threaded fasteners and, 592
  - threaded fasteners and, 590, 592, 594
- Pirbhai, Imtiaz A., 57
- Placement
  - conventional, principal views, 348
  - dimensioning, standard practices, 505-506
- Plain head keys, ANSI standard, A-43
- Plain washers, 605
- Planar surfaces, visualization and, 281-287
- Plane of projection, 340
- Planes, 268; *see also* Axonometric drawings/projections
  - changes of (corners), multiview representations, 370
  - configuration of, orthographic projection principle, 368, 370
  - cutting; *see* Cutting planes
  - and edges; *see* Edges/Edge views
  - foreshortened, 368
  - horizontal; *see* Horizontal plane
  - inclined; *see* Inclined edges/lines/planes
  - isometric, 414
  - on multiview drawings, 340, 341-343, 364, 370
  - nonisometric, 418
  - oblique, isometric axonometric, 424-425
  - picture, 447
  - principal, fundamental views of, 364-365
  - of projection, 342-343
- Planning, 14
- Planning activity, 14-16
- Platform products, 19
- Plus and minus dimensioning, 503
- tolerance representation and, 524
- Pointer, mouse, 661
- Points, 272
  - on multiview drawings, 368
- Pojman, Louis P., 140
- Popular Science*, 46
- Polaroid cameras, 19
- Pollutants
  - chlorofluorocarbons (CFCs), 135
  - polychlorinated biphenyl (PCB), 135, 136
  - trading pollution reductions, 134
  - cadmium from Mitsui smelters, 135
  - mercury pollution from Chisso Co., 135
  - crossing national boundaries, 134
- POLYGON command, 600
- Position
  - GDT and; *see* Geometric dimensioning and tolerancing (GDT)
  - geometric controls for, 555-558
- Positive interdependence, 148
- Posner, Barry Z., 153, 154, 162
- Postmortem project evaluation, 176
- Postmortem report, 176
- Potential teams, 146
- Power equation, 700
- Power transmission, threaded fasteners and, 591
- Pratt & Whitney key, 606
- Precedence of lines, 264
- Precision fit calculation, standard precision fits (English units), 539
- Precedences, operator, 665
- Preferred fits
  - hole basis metric clearance, A-11
  - hole basis transition and interference, A-12
  - metric, A-10
  - limits and, 532-534
  - shaft basis metric clearance, A-13
  - shaft basis transition and interference, A-14
- Preferential Treatment: Is It Ever Justified?* 123-124
- Preferred precision fits, 534
- Prejudging Prejudices of a New Manager*, 123-124
- Preventive technology, 105
- Preview, Print, 681
- Primary axes, 288-289
- Primary datum, 547
- Primary needs, 35-36
- Primitives, solids/shapes
  - multiview drawings of, 369
- Principal planes, 364-365
- Principal (standard) views, 261, 263, 290, 292
- Principal views, in multiview drawings; *see* Multiview drawings
- Print Preview, 681
- Printing a worksheet, 681
- Prisms, cylinders intersecting, 380
- Pritchard, Michael S., 119
- Privacy at Risk*
  - Personality Test Questions, 121-122
  - Search of Engineer's Desk, 121-122
  - Security of Private Finances, 122
  - Spying on Union Organizers, 122
  - Surveillance Cameras at Work, 121-122
- Problem clarification, 64-66
  - focus on subproblems, 66
  - problem decomposition, 64-66
- Problem decomposition, 64-66
- Problem solving, visualization for design and, 276-278
- Process documents, 174
- Process-intensive products, 19
- Product attributes, 54-55
- Product champion, 83
- Product concept, 61-62
- Product development
  - concept development, 16-18
  - concept generation, 61-64
  - cost model, 52-53
- Product development organizations, 21-24
- Product development process
  - accelerating, 170-173
  - at AMF Bowling, 19-20
  - applying concept selection throughout, 92
  - concept development, 27-28
  - concept selection, 81-82
- customized products, 19-20
- definition, 14
- generic, 13-17
- platform products, 19
- process-intensive products, 19
- technology-push products, 18-19
- usefulness, 13-14
- Product development speed, 23-24
- Product development team, 27; *see also* Project team
- Product evaluations, 46
- Product introduction, 85
- Production cycle, 575
- Production-intent parts, 16
- Production ramp-up, 16
- Product launch, 16-17
- Product-process coordination, 85
- Products
  - technical models, 51-52
  - use environment, 27
- Product specifications
  - definition, 42
  - final, 51-56
  - setting target specifications, 43-51
  - stages in establishing, 43
- Product-use observation, 30
- Professional societies: moral support, 106
- Professional
  - judgement, 106
  - conscience and obligations, 120
  - duties and rights, 120-121
- Profile image plane, 290
- Profile plane, 365
- Profile plane of projection, 342-343
- Profile(s)
  - image plane, 290
  - plane, 365
  - of projection, 342-343
  - views, 342, 473
- Profile views, 342, 473
- Profit margins, 58-59
- Project-based performance measures, 174
- Project budget, 169-170
- Project buffer, 172, 175
- Project control, 163
- Project execution, 163
  - assessing project status, 174-175
  - basic problems, 173
  - coordination mechanisms, 173-174
  - corrective actions, 175-176
- Project management
  - accelerating projects, 170-173
  - baseline project plan, 167-170
  - critical chain method, 172
  - definition, 163
  - postmortem project evaluation, 176-177
  - project execution, 173-174
  - understanding and representing tasks
    - critical path, 166
    - design structure matrix, 164-165, 179-180
    - Gantt charts, 165-166
    - PERT charts, 166
    - sequential, parallel, and coupled tasks, 163-164
- Project managers
  - heavyweight, 22

lightweight, 22  
 Project milestones, 169-170, 175  
 Project organizations  
   characteristics, 22  
   merits of, 23-24  
   Project planning, 17-18, 163  
   importance of, 167  
 Project reviews, 175  
 Project risk areas, 170  
 Project schedule, 169-170  
 Project scope, changes in, 176  
 Project scope management, 171  
 Project status assessment, 174-175  
 Project task list, 168  
 Project team, 4  
   concept selection methods, 83-84  
   corrective actions, 175-176  
   definition, 23  
   economic analysis, 18-19  
   improving performance, 175-176  
   incentives, 174  
   informal communication, 174  
   kinds of, 22-23  
   located together, 175  
   meetings, 174  
   outside resources, 176  
   staffing and organization, 168-169  
   staffing changes, 175  
   weekly updates, 174  
 Projection(s); *see also* Orthographic  
   projection; Sketches  
   axonometric; *see* Axonometric  
   drawings/projections  
   first angle, 349-352  
   lines, 288  
   plane of, 340  
   planes, multiview drawings and, 341-343  
   studies, visualization, 381  
   third angle, 349-352  
 Projection theory  
   auxiliary views; *see* Auxiliary views  
   oblique, 439  
 Projects, 21  
 Promotive interaction, 148  
 Proof-of-concept models, 18  
 Proportion, sketching and, 247-250  
 Prototypes, 16, *see also* Models  
 Prototyping, 18, 84-85  
 Protractors, 198, 199  
 Pseudo learning group, 146  
 Pseudo teams, 146  
 Published literature searches, 67  
 Pugh, Stuart, 86, 93  
 Pugh concept selection, 86

**Q**  
 Quadrant, of a circle, 331  
 Quality assurance, 13-14  
 Quality Function Deployment, 44  
 Quantitative goals, 70-71

**R**  
 r-squared value, 708  
 Radial leader lines, 510  
 Radial line, 510  
*Radiation Experiments Without Consent*, 104

Radius, 504  
   of a circle, 330  
   vs. diameter, detail dimensioning, 512  
   dimensions, 504  
 Radius symbol, 504  
 Raiffa, Howard, 93  
 Ramaswamy, Rajan, 57  
 Range, 669  
 Ranking concepts, 87, 90  
 Rating concepts, 87, 90  
 Rayner, Steven, 158, 162  
 Reading direction, dimensioning, 508  
 Real teams, 146  
 Rear view, 346  
 Receding axis angles, 441  
 Rechlin, Eberhardt, 57  
 Rectangular coordinate dimensioning, 505  
 Rectified arcs, 333-334  
 Recycling computers, 137  
 Reder, M., 596  
 Reed, George L., 117  
 Reference, cell, 10, 43  
 Reference concept, 87  
 Reference dimension, 503  
 Reference points, 90  
 Refinement, 16  
 Refinement, design and; *see* 3-D  
   modeling/analysis  
 Regan, Tom, 141  
 Regression feature, in Excel, 711, 712  
 Regular curve, 320-321  
 Regular isometric drawing, 417  
   regulations, 107-108  
   specific vs. broad, 109  
 Regulatory agencies, 108  
 Reich, Robert B., 127  
 Reinertsen, Donald G., 168, 170  
 Related stimuli, 70  
 Related views, multiview drawings, 352  
 Relationships, 151-152  
 Relative cell address, 676  
 Removed views, 391, 477-478  
 Removing worksheet items, 658  
 Repetitive features, dimensioning, standard  
   practices, 508  
 Reporting relationships, 21  
 Reproduction, reprographics and, 574  
 Reprographics, 574  
 Rescher, Nicholas, 142  
 Responsibilities as an employee, 113  
 Responsible engineering, major elements, 104  
 Retaining rings, 604  
 Retrieving a worksheet, 680  
 reverse engineering, 113  
 Reversed axis isometric, 334  
 Revision blocks  
   on drawings, 274  
   working drawings and, 585  
 Revolution, 364, 449  
 Revolution conventions, 390-391  
 Revolved section, 477  
 Reynolds, T.S., 223  
 Ribs (webs), 484-486, 487  
 Right- and left-hand threads, 594  
 Right side view, 345-346  
 Rights:

  as human beings, 120  
   voluntary or involuntary, 103  
 Rights as professionals:  
   as employees, 121  
   privacy, 121-122  
   professional conscience, 120  
   reasonable remuneration, 121  
   recognition, 121  
   contractual, 120  
 Risk identification, 170-171  
 Rivets, 607  
 Rock Shoe, Inc., 484  
 Rockefeller, John D., 151  
 Rodman, Dennis, 148  
 Rodriguez, W., 294  
 Roots, 592  
 Rosenfeld, Michael, 188  
 Rounds, 373, 376, 437  
 Rows, inserting and deleting, 676-677  
 Running and sliding fits (RC), 535, A-5  
 Runouts, 373, 376, 437  
 Russian problem-solving methodology, 70-71  
 Ryffell, H.H., 609

## S

*Sacred Hoops* (Jackson & Delahanty), 148  
 Saving a worksheet, 686  
 SAE grades for fasteners, 595  
 Safe exit, 99  
   lack of, 134  
*Safety: Buyer Beware or Seller Beware?*, 104  
 Safety times, 172  
 Salvadori, Mario, 104  
 Scale(s)  
   architect's, 210-211  
   civil engineer's, 211-2131  
   combination, 209, 214  
   mechanical engineer's, 213-215  
   metric, 215-216  
   as tools, 209-216  
   working drawings and, 585-586  
 Scale compression, 90  
 Scaling data (curve fitting), 728  
 Scatter charts, 687, 692  
 Schedule display, 174  
 Schematic drawings, 597, 598, 600  
 Scholtes, Peter R., 148, 149, 154, 156, 162  
 Schrage, Michael, 145-146, 148, 150  
 Schumacher, E. F., 128  
 Schweitzer, Albert, 141  
 Scoring matrix, 86  
   preparing, 89-90  
 Screening matrix, 86-87  
 Screws, standard, 601-604  
 Screw threads, 592  
   detail, 514  
   isometric axonometric, 437  
   oblique, 445-446, 451  
   oblique/axonometric, 409  
 Scroll bars, 656, 658, 662  
 Scroll button, 658  
 SDRC, 339, 583  
 Secant, of a circle, 330  
 Secondary datum, 547  
 Secondary needs, 35  
 Sectioned assembly, 580



- Section lines, 202-203, 472  
 Section views, 463-498, 580  
   aligned sections, 486-487  
   assembly, 478-480, 482, 484, 580, 582  
   auxiliary, 480-483  
   broken-out, 477  
   CAD techniques, 467-468, 472, 486  
   conventional breaks, 487-488  
   cutting plane lines, 471-472, 473  
   cutting planes in, 464, 469  
   edges in, 469  
   full, 476  
   half, 476-477  
   hidden features and, 464-467, 468  
   horizontal, 458  
   isometric axonometric, 436-437  
   line practices, 473-476  
   lugs, 485-486  
   oblique, 445  
   offset, 478  
   removed, 391, 477-478  
   revolved, 477  
   ribs, 484-486  
   special conventions, 483-487  
   surfaces in, 469  
   thin features, 484-486  
   types of, 476-484  
   visualization and, 468-470  
   webs, 484-486  
 Sector, of a circle, 330  
 Segment, of a circle, 331  
 Selecting cells, 671  
 Semicircle, 330  
 Semi-ellipses, sketching, 256, 257  
 Semi-log graphs, 697  
   three-cycle, 697  
 Sentient-Centered Ethics, 140  
 Sequencing design structure matrix, 165  
 Sequential tasks, 163-164  
   in Gantt chart, 165  
   Shiba, Shoji, 38  
 Series, thread specifications, English system, 593, 595  
 Set screws, 600, 603  
   hex and spline socket, A-32, A-33  
   slotted headless, A-32  
   square head, A-34  
 Sexual harassment, 122-123  
 Shading, of sketches, 239  
 Shaft basis, 532, 534  
 Shaft diameter vs. key size, A-43  
 Shaft system, 538-539  
 Shakespeare, William, 237  
 Shape, 279  
*Shared Minds* (Schrage), 148  
 Sharp-v threads, 593  
 Shaw, Gaylord, 103  
 Sheet metal gage table, 516  
 Shipbuilding, 548, 607  
 Shortcuts, editing, 679  
 Shoulder screws, A-27  
 Shrivastava, Paul, 12SI (System International), 215, 500  
 Side, 592  
 Side view, 343  
 Siedner, C. J., 149  
 Silicon Graphics Computers, 223  
 Similar shapes, visualization of, 384-385  
 Simplified representations, 597, 599, 600  
 Singer, Peter, 140  
 Single-curved lines, 320  
 Single-curved surface, 285-286  
 Single limit dimensions, 524  
 Single thread, specifications, 593-594  
 Single view, 342  
 Size, 504, 529, 535  
 Sketches, 237-316  
   axonometric, 250  
   CAD and, 240, 242, 254  
   curved lines, 245-246  
   cylinders, isometric pictorial, 255-256, 257  
   ellipses, isometric pictorial, 254-255  
   hand/eye/mind connection, 277  
   isometric, 250-256, 2571  
   lettering; *see* Lettering  
   multiview; *see* Multiview drawings  
   oblique, 250  
   perspective, 250  
   pictorial, 251-259  
   projections, 250-263  
     isometric, 251-256  
       cylinders, 255-256, 257  
       grid paper for, 242, 256-258, 411  
       vs. oblique, 259  
       semi-ellipses, 256, 257  
     oblique pictorials, 258-259  
   proportions, 247-250  
   shading of, 239  
   technical, 238-242  
     CAD sketching, 240, 242, 254  
     freehand, 240-242  
   technique for, 242-246  
     curved lines, 254-246  
     straight lines, 243-244, 318-320  
   text on drawings, 274-275  
   three-view, 266-268  
   two-view, 265-266  
   visualization; *see* Visualization  
 Slots, 511, A-25, A-31, A-32  
 Slotted filler head cap screws, A-25  
 Slotted flat countersunk head cap screws, A-25  
 Slotted flat head metric machine screws, A-31  
 Slotted headless set screws, A-32  
 Slotted round head cap screws, A-25  
 Smith, Douglas K., 146, 147, 148, 149, 158, 161,  
   161,  
 Smith, Karl A., 148, 149  
 Smith, Preston G., 168, 176, 178  
 Smith, Robert P., 165, 177, 178  
 Smoothing, 156  
 Sobek, Durward K., II, 173, 178  
 Solomon, Sorin, 79  
 Sony Walkman, 19, 20  
 Souder, William E., 92  
 SNAP command, 205  
 Social experiment, 101  
 Social experimentation, 128  
*Social Experimentation Model*, 104  
 Socket head cap screws - metric series, A-28  
 Socket head cap screws (1960 series), A-18  
 Solid objects, 278-281, 369  
 Soyuz space station, 515  
 Space curves, 379  
 Space Stations, 335, 515  
 Spacing, standard practices, dimensioning, 506  
 Specialists, and technical drawings, 193-194  
 Specialized Bicycle Components, 41, 58  
 Specifications, 27  
   working drawings and, 575  
 Sperlich, Harold K., 145  
 Spheres, isometric axonometric, 435-436  
 Spline, 208, 379, 488  
 SPLINE command, 379, 488  
 Spline socket head cap screws, A-26  
 Spotfaced holes, 373  
 Spotfacing, 373, 514  
 Spreadsheet, 655  
 Spreadsheet features, 655  
 Spring force, 696, 703  
 Square end pins, A-44  
 Square errors, sum of (SSE), 708  
 Square grid papers, 242  
 Square head bolts, A-19  
 Square head nuts, 602  
 Square head set screws, A-34  
 Square machine screw nuts, A-24  
 Square nuts, A-21, A-24  
 Square thread, 592, 593  
 SSE, 708  
 SST, 708  
 Stack-up, of tolerances, 528-529  
 Staedtler, Inc., 198, 218, 220  
 Staffing, 168, 169  
 Staffing changes, 175  
 Staggering, grouping and, dimensioning,  
   standard practices, 506-507  
 Standard practices, dimensioning, size and  
   location, 505-509  
 Standard precision fits (English units), 535-540  
 Standard representations of various geometric  
   forms, 382  
 Standards, 193, 389, 418, 600-601; *see also*  
   American National Standards  
   Institute (ANSI)  
   descriptive, 110  
   for dimensions, oblique/axonometric  
     drawings, 446  
   for sectioning assemblies, 580  
   graphics communication, 191-193  
   industrial, 109  
   international (ISO), 109-110  
   performance, 110  
   sheet metal gage table, 516  
   types of, 109-110  
 Starr, Jerold M., 138  
 Starting early, 171  
 Start-ups, 22  
 Station point, 447, 451  
 Statistical process control, 541  
 Status bar, 655, 658  
 Status memo, 174  
 St. Clair, Lynda, 137  
 Sterba, James, 142  
 Stereolithography, 360  
 Sterrett, Jonathan, 27  
 Steward, Donald V., 177  
 Still photography, 32-33  
 Stimuli, 70-71



- Stitch lines, 202-203
  - Stix, Gary, 128
  - Streibel, Barbara J., 148, 149, 156, 162
  - Straightedges, 198
  - String, 655, 663
  - String operator, 664
  - Striving for Excellence in College* (Browne & Keeley), 146
  - Structural analysis, 608
  - Studs, 600
  - Subassembly, drawings, 578
  - Subjective selection criteria, 91
  - Submission to an authority, 106-107
  - Subtraction operator, 664
  - Subtractive technique, 281
  - Sugarman, Robert, 101
  - Sum of square errors (SSE), 708
  - Supreme Court of US: *Hydroleve v. ASME*, 111
  - Surface profile, orientation, 553, 534
  - Surfaces
    - curved
      - multiview representations, 371-372
      - oblique/axonometric, 443-445
    - finished, 373-376
    - labeling, visualization and, 385
    - oblique, 435, 443, 445
    - section views and, 469
  - Suspending judgment, 69
  - Suspensions, adjustable, mountain bikes, 484
  - Sustainable development, 128
  - SYMBOL command, 221
  - Symmetry, 202-203, 285, 558
  - Symmetry lines, 202-203
  - Sympathetic listening, 153
  - System-level design, 16
  - System tolerance, 525
  - Systematic exploration, 70-78
    - concept classification tree, 72-73
    - concept combination table, 73-76
    - management of, 76-77
  - Systems engineering, 56
- T**
- Tablets, 195-196
  - Tabs, worksheet, 656, 657
  - Tabular drawings, 587-589
  - TANGENT command, 322
  - TANGENT snap feature, 330
  - Tangent/Tangencies, 318, 321-330, 331
    - arc to a line and an arc, 324-326
    - arc to a line at a given point, 323
    - arc to two arcs, 327-328
    - arc to two lines, 324
    - between circle/arc and line, 323
    - to a line at a point, 323
    - lines to two circles, 328-330
    - between two circles, 323
  - Tap drills
    - sizes, A-17
    - threaded fasteners and, 592
  - Taper pins, A-44
  - Taper pipe threads (NPT), A-35
  - Taps, threaded fasteners and, 592
  - Target cost, 52
  - Target costing, 58-59
  - Target specifications, 17, 43
    - acceptable value for each metric, 47, 49
    - benchmarking information, 47-48
    - evaluating results, 49-51
    - list of metrics, 43-44
    - needs-metric matrix, 44-46
    - steps, 43
  - Target values for metrics, 47-51
  - Task dependencies
    - critical path, 166
    - design structure matrix, 164-165
    - Gantt charts, 165-166
    - PERT charts, 165-167
    - in product development, 163
    - sequential, parallel, and coupled tasks, 163-164
    - types of, 164
  - Task duration, 172
  - Task roles, 152
  - Tasks, 151-152
  - Tasks
    - decoupling, 173
    - outsourcing, 172
    - pipelining, 172-173
  - Taylor, D.L., 294
  - Taylor, James, 153, 161
  - Taylor, James R., 38
  - Taylor, Paul W., 141
  - Team charter, 153
  - Team development, 156
  - Team effectiveness, 148
  - Team Handbook (Scholtes et al.), 154, 158
  - Team performance, advice on, 148
  - Team staffing and organization, 168-1691
  - Teams; *see also* Learning teams,
    - categories of, 146
    - compared to groups, 147
    - effective, 145-146
    - literature on, 148
    - challenges and problems, 157-158
    - importance of diversity, 147-148
    - literature on, 148
  - Teamwork, 113
  - Teamwork skills, 148
    - communication skills, 153
    - conflict management, 156-157
    - decision making, 154-156
    - group norms, 152
    - leadership, 153-154
    - tasks and relationships, 151-152
  - Technical drawings/graphics, 186-188; *see also* Sketches
    - computer-aided tools for, 194-197
    - specialists and, 193-194
    - tools for
      - alphabet of lines, 202-204
      - compass, 219-220
      - computer-aided, 194-197
      - dividers, 219-220
      - drawing instrument set, 218-220
      - line drawing, 204-209
        - at angles relative to a given line, 207-208
        - erasing, 205
        - French curves, 208-209
        - horizontal lines, 204
        - inclined lines, 205
      - irregular (French) curves, 208-209
      - parallel lines, 206
      - perpendicular lines, 206-207
      - through two points, 205, 206
      - vertical lines, 204-205
    - technique for using, 221-222
    - templates, 220-221
    - traditional, 197-201
      - drawing paper, 199-200
      - mechanical pencils, 199
      - pencils, 199, 200
      - protractors, 198, 199
      - straightedges, 198
      - triangles, 201, 207-208
  - Technical models, 51-52
  - Technical sketches; *see* Sketches
  - Technologists, 186
  - Technology assessment, 138
  - Technology platform, 19
  - Technology-push products, 18-19
  - Technology transfer, 127-128
  - Tektronix, Inc., 197
  - Terninko, John, 79
  - TEMPLATE command, 221
  - Templates, 220-221
    - for circles, 220-221, 331
    - ellipse construction and, 430
    - fasteners and, 574
    - lettering, 268, 269
  - Temporary fasteners, 577
  - Tertiary datum, 547
  - Tesla, Nikola, 275
  - Testing, 84
  - Testing and refinement, 16
  - Teton Dam*, 103
  - Texas Instruments Ethics Office, 117
  - Text
    - alignment of, CAD lettering, 272-274
    - height of, 503
    - CAD lettering, 272
    - lettering; *see* Lettering
    - placement, 506
    - styles, alternate, lettering, 271-272
  - Text alignment, CAD lettering, 272-274
  - TEXT command, 472
  - Text constant, spreadsheet, 655
  - Thatcher, Charles, 470
  - Theobald, Robert, 138
  - Theory of inventive problem solving, 70
  - Thin features, 484-486
  - Thin-lead pencils, 199
  - Thin wall sections, section line practices, 474-476
  - Third-angle projection, 349-352
  - This Old House*, 67
  - Thomas Register of American Manufacturers*, 68
  - Thomas, T.A., 454
  - Thousandths, 539
  - Thrall, Charles A., 138
  - Thread angle, 592
  - Threaded fasteners, 589-600
    - applications, 590-591
    - lead, 590
    - pitch, 592
    - specifications

- English system, 592-595
    - metric system, 595-597
  - terminology, 591-592, 594
  - thread drawings, 597-600
  - Thread form, 592-593, 596, A-17
  - Thread(s); *see also* Threaded fasteners
    - angle, 592
    - grades, 595
    - notes on, 594-595
    - per inch, 592
    - pitch of, 594
    - sizes and dimensions, A-16
    - specifications for, 592-597
  - Thread series, 592, 593, 595, A-15
  - Threads per inch, 592
  - 3-D modeling/analysis
    - concurrent engineering and, 589
    - data visualization elements; *see* Visualization models, 190
    - multiview drawings from, 358-361
    - shipbuilding, 548
    - workplanes, 360
  - Three-point perspective drawings, 450
  - Three-view drawings/sketches, 266-268, 354-358
  - Through hole, 372-373
  - Tichy, Noel M., 137
  - Tightness, classes of fit, 593
  - Timing of product introduction, 85
  - Titanic*, 108-109
  - Title bar, 655-656
  - Title blocks
    - on drawings, 274
    - working drawings and, 583
    - ANSI standards, 520-522
  - Tolerance, 499, 504, 524
    - ANSI standards and, 520-522
    - in CAD, 540-541
      - associative dimensioning and, 541
      - geometric accuracy and, 541
    - calculations, 558-559
    - classes of fit, threaded parts, 593
    - defined, 535, 532
    - geometric; *see* Geometric dimensioning and tolerancing (GDT)
    - interchangeability and, 522-523
    - maximum material condition (MMC) and, 544-545
    - metric limits and fits; *see* representation of representation of, 523-540
      - actual size, 524
      - allowance, 524-525
      - basic size, 524
      - costs of tolerance, 527
      - fit type determination, 527
      - fit types, 525-527
      - functional dimensioning, 527-528
      - important terms, 524-525
      - least material condition (LMC), 525
      - limit dimensions, 524
      - maximum material condition (MMC), 525
      - metric limits and fits, 529-534
        - basic size, 529
        - deviation, 529
        - fundamental deviation, 529
      - hole basis, system, 532-534
      - international tolerance grade (IT), 532
      - limit form, 534, 535
      - lower deviation, 529
      - note form, 534, 535
      - preferred fits, 532-534
      - shaft basis, system, 532-534
      - symbols, 531-532
      - tolerance zone, 529, 532, 548
      - upper deviation, 529
    - nominal size, 524
    - piece tolerance, 525
    - plus and minus dimensions, 504, 524
    - single limit dimensions, 524
    - standard precision fits (English units), 534-540
      - basic hole systems, 535-538
      - basic shaft system, 538-539
      - basic size, 535
      - classes of, 534-535
      - clearance fit, 535-538
        - using basic shaft system, 539
      - precision fit calculation, 539
      - system tolerance, 525
      - tolerance stack-up, 528-529
    - specifications, working drawings and, 586-587
    - stack-up, 528-529
    - tolerancing, 522-523
    - zone, 529, 532, 548
      - metric limits and fits, 529
  - Tolerance zone, 529, 532, 548
  - Tony Stone Images, 188, 500
  - Toolbar, chart, 687
  - Toolbars, 656-657
  - Tools, 193
  - Top view, 342, 343, 345
  - Toyota Motor Company, 173
  - Tracing paper, 242
  - Trade-offs
    - on final specifications, 53-56
  - Trade secrets, 113-115
  - Trade Secret*, Wohlgemuth / Goodrich, 118-119
  - Traditional classroom learning group, 146-147
  - Traditional engineering design, 188
  - "Tragedy of the commons", 133
  - Train seats, 334
  - Transitional locational fits (LT), A-7
  - Transition fits, 527, 535, A-7
  - Transition locational fits (LT), 535
  - Tregoe, Benjamin B., 93
  - Trendline, 709
  - Triangle method, 319-320
  - Triangles, 201, 207, 208
  - Trigonometry functions, A-4
  - TRIM command, 205
  - Trimetric projection, 414
  - Triple-thread fasteners, 593
  - TRIZ problem-solving method, 70-71
  - True isometric ellipses, 426-429, 434
  - True length and size, orthographic projection and, 364
  - True-length line, 364
  - Truss head fastener, 602
  - TRW Ross Gear Division, 599
  - Turgenev, Ivan S., 413
  - 12-point head fastener, 602
  - Two-dimensional surfaces; *see* Engineering geometry
  - Two-point drawings/sketches, 450
  - Two points, line drawing techniques and, 205-206
  - Two-view drawings/sketches, 265, 266, 354, 356
  - Type A plain washers, A-37
  - Type B plain washers, A-38
- ## U
- Ucello, Paolo, 362
  - Ui, Jun, 136
  - Ulrich, Karl T., 57
  - Undoing changes, 675
  - Underwriter Laboratories (UL), 110
  - Unfinished bolts, 601
  - Unger, Stephen H., 106, 112
  - Unidirectional dimensioning, 494
  - Unified National Round thread, 593
  - Unified standard screw thread series, A-15
  - Unified thread, 593, A-15
  - Unilateral tolerance, 524
  - U.S. Army Corps of Engineers, 136
  - U.S. Military (MIL) Standards, 192
  - Union Carbide (Bhopal), 128
  - Unions and Engineers, 124
  - United States Patent and Trademark Office, 67
  - Units of measure, dimensioning and, 500-501
  - Unrelated stimuli, 70-71
  - Upper deviation, metric limits and fits, 529
  - Upper limit, 522
  - Urban, Glen L., 38, 47, 57, 90, 93
  - Use environment, 27
  - User actions, 66
- ## V
- Value Axis, 687
  - Valve Malfunctions*, 100
  - VanDeVeer, Donald, 140
  - VanGundy, Arthur B., Jr., 70, 79
  - Vanishing point, 448, 451
  - Variable substitution, 726
  - Vertex/Vertices, 278-279, 386
  - Vertical axis, 288-289
  - Vertical dimensions, 504
  - Vertical lines, 204-205
  - Vertical position, 505
  - Vesilind, P. Aarne, 140
  - Video recording, 32
  - Vierick, Charles J., 316, 497
  - Views, 342, 343
    - auxiliary; *see* Auxiliary views
    - bottom, 346
    - central, 353
    - dimensioning of, standard practices, 508, 509, 510
    - edge; *see* Edges/Edge views
    - front, 260, 343, 345
    - multiple sectioned, cutting plane lines and, 473
    - one-view drawings/sketches, 354, 356

- principal (standard); *see* Principal (standard) views
  - rear, 346
  - related, multiview drawings, 353
  - removed, 477-478
    - ANSI standards for, 391
  - right side, 345-346
  - selection of, 361-364
  - top, 342, 343, 345
  - Virtual colocation, 175
  - Virtual condition, 548-549
  - Virtual reality (VR), 202
  - Virtus Corp., 240
  - Visible gap, 503
  - Visible lines, 202-203
  - Visualization, 193
    - for design, 275-278
    - for engineering drawings, 287-292
      - image planes, 287-292
      - multiple image planes, 289-292
      - object-image plane orientation, 288-289
      - view, choosing, 292
  - multiview, 381-389
    - adjacent areas, 383-384
    - analysis by solids, 386-387
    - analysis by surfaces, 388-389
    - missing lines, 385-386
    - physical models, 381-383
    - projection studies, 381
    - representations of geometric forms, 382
    - similar shapes, 384-385
    - surface labeling, 385
    - vertex labeling, 386
  - section views and, 468-470
  - sketching text
    - cutting planes, 281-284
    - for design, 275-278
      - problem solving and, 276-278
    - general, 279-287
    - negative solids, 279-281
    - planar surfaces, 281-287
    - solid objects and, 278-281
    - surface models (development), 285-287
    - symmetry and, 285
  - Von Hippel, Eric, 30, 31, 38
  - Von Oech, Roger, 70, 79
- W**
- W. L. Gore Associates, 18
  - Wade, Wynn C., 100
  - Waiting delays, 172
  - Walden, David, 38
  - Wallach, Lori, 133
  - Ward, L., 294
  - Washer face, 601
  - Washer head fastener, 602
  - Washers, 601, 604-605
  - Weapons for war, 142
  - Weaver, R., 609
  - Web sites, 41, 223
  - Webs (ribs), 484-486
    - symbols, A-47 to A-50
  - Weekly status memo, 174
  - Weekly updates, 174
  - Welch, John F., 151
  - Wells, Paula, 112
  - What-if, 655
  - What-if cost analysis, 52
  - What's This?, 659
  - Wheelwright, Steven C., 26, 167, 177
  - "When in Rome...", 130
  - Whistleblowers, 125
  - whistleblowing:
    - definition, 125
  - Whitehead, Alfred North, 573
  - Whitworth, Joseph, 590
  - Width, column, 677
  - Wilde, Douglass J., 148
  - Wisdom of Team* (Katzenbach & Smith), 148
  - Withdrawal, 156
  - Wizard, Chart, 687
  - Wohlgemut, Donald, 114
  - Wolgast, Elizabeth, 106
  - Woman Engineer Expecting a Baby*, 124
  - Wood, Kristin L., 93
  - Woodruff keys, 606-607, A-41, A-42
  - Working assembly drawing, 589
  - Working drawings, 573-574
    - assembly, 578, 580, 589
    - basic concepts, 574
    - bolts, studs, and screws, 600-604
      - bolts, standard, 600-601
      - CAD, 604
      - cap screws, 600, 602-603
      - head style design, 602
      - locking devices, 604
      - machine screws, 600, 603
      - nuts, standard, 601
      - screws, standard, 601-604
      - set screws, 600, 603
      - standard, 600-604
      - studs, 600
      - templates, 604
    - detail, 575-578
    - drawing numbers, 580
    - nonthreaded fasteners, 604-607
      - keys, 606-607
      - pins, 605-607
      - rivets, 606, 607
      - standard washers, 605
    - part identification and, 584-585
      - numbers, 580
    - pipng; *see* Piping drawings
    - revision blocks and, 585
    - scale specifications, 585-586
    - tabular, 587-589
    - threaded fasteners; *see* Threaded fasteners
    - title blocks and, 583
    - tolerance specifications and, 586-587
    - zones and, 587
  - Work, fragmentation, 107
  - Workplace responsibilities and rights, 113
  - Workplace safety, 131-132
  - Worksheet, 655, 656, 657, 661
    - editing, 671
    - moving around, 661
    - printing, 681
    - retrieving, 680
    - saving, 680
  - Worksheet cell, active, 656, 657, 661
  - Worksheet tabs, 656-657
  - Worksheet window:
    - adding items, 658
    - removing items, 658
  - World Trade Organization* (WTO), 133
  - World Wide Web (WWW), 223, 515
  - Worm's eye view, 450
  - Worthy, Ward, 129
  - Wyman, J.D., 394
- X**
- x-y chart, creating, 693
  - XY charts, 687, 692
  - x-y graphs, 687, 692
- Y**
- Yarrow Bridge Editorial, 101
  - Young, B., 609
- Z**
- Zau, Gavin, 61
  - Zlotin, Boris, 79
  - Zones, working drawings and, 587
  - Zusman, Alla, 79