1) Analyzing the product and the process
   a) production scale
   b) adding value
   c) how would you make this by hand?
   d) what is your required production rate?
   e) part tolerances
2) Documentation
   a) Memos
   b) Reports
   c) Drawings & part lists
3) Feeding & Fabrication
   a) Material removal
      i) CNC
      ii) Rotating work
         (1) lathe
         (2) turning center
      iii) Rotating tool
         (1) vertical mill
         (2) horizontal mill
         (3) machining center
         (4) clamping and fixturing
      iv) Feeds & Speeds
      v) Automatic screw machines
      vi) Centerless grinding
   b) Forming
      i) sheet metal
         (1) folding
         (2) punching
         (3) shearing
      ii) extruding
      iii) sintering
      iv) molding and casting
   c) Joining
      i) Rivets
      ii) press-fit fasteners
      iii) Threaded fasteners
      iv) Snap fastening
      v) Adhesives
      vi) Welding
   d) Feeding parts
      i) orientation and symmetries
      ii) conveyors
      iii) vibratory feed bowls
      iv) pick & place
4) Generating motion
   a) linear motion
      i) pneumatic cylinders
      ii) electric solenoids
      iii) vibratory systems
   b) rotary motion
      i) DC motors

        ii) AC motors
- (1) stepper
- (2) brushless
- (3) induction

   c) conversion between rotary and linear
- i) lead screws
- ii) rack & pinion
- iii) four-bar linkages

5) Control of motion
   a) On/off control
- i) pneumatic logic
- ii) electric controls
  - (1) relays
  - (2) programmable logic controllers (PLC)
    - (a) digital logic
    - (b) ladder diagrams
    - (c) timing diagrams
    - (d) state machines
      - (i) state diagrams
      - (ii) state transition tables
      - (iii) state logic equations
      - (iv) RLL-Plus stage programming
    - (e) input and output
      - (i) DC
        1. sinking
        2. sourcing
      - (ii) AC
    - (f) higher level functions
      - (i) timers
      - (ii) counters
      - (iii) math
  - (3) position sensing
    - (a) mechanical
    - (b) optical
      - (i) modulated/non-modulated
      - (ii) reflective/transmissive
      - (iii) light on/dark on
      - (iv) fiber optic
    - (c) magnetic
      - (i) reed switch
      - (ii) hall effect
      - (iii) inductive proximity

   b) Proportional control
- i) sensors
  - (1) resistive and bridges
  - (2) optical
    - (a) incremental
    - (b) absolute
  - (3) PLC highspeed I/O
    - (a) highspeed counter
    - (b) quadrature counter

             (c) stepper drive
- (4) magnetostrictive
- (5) 4-20mA interface
- (6) PLC analog I/O
- ii) PID controllers
  - (1) PLC PID control functions
  - (2) Basic control theory
    - (a) P,I,D control
    - (b) PI, PD, and PID composite control
    - (c) analog and pneumatic controllers
- c) Factory communications
  - i) wiring
    - (1) noise sources
      - (a) common impedance coupling
      - (b) magnetic field coupling
      - (c) electric field coupling
    - (2) twisted-pair
    - (3) coax (and twin-ax)
    - (4) shielding and grounding
    - (5) transmission line theory
      - (a) reflections
      - (b) termination
  - ii) signalling
    - (1) RS-232
    - (2) RS-485
    - (3) Ethernet
  - iii) protocols
    - (1) master/slave vs. peer-to-peer
    - (2) deterministic vs. asynchronous
    - (3) examples
      - (a) TCP/IP
      - (b) DeviceNet
  - iv) PLC communications
- d) Human/machine interface (HMI or MMI)
  - i) system control
  - ii) data acquisition
  - iii) analysis and display
  - iv) factory database
  - v) resource and work-in-process tracking
  - vi) statistical process control
  - vii) alarms and logging
6) Additional topics not really covered
   - a) Non-discrete manufacturing
     - i) web materials
     - ii) continuous flow processes
   - b) Efficiency and effectiveness
     - i) Just-In-Time
     - ii) Flexible manufacturing
   - c) Throughput and production rate
     - i) Jams & malfunctions
     - ii) buffers

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