This document summarizes some major essential points you should pay attention to when you review the lecture notes to prepare for the final exam. Please read the lecture notes for the actual contents. Please also note that this summary does not necessarily cover all the contents we have taught this semester, and hence it does NOT necessarily cover all the contents for which we may give problems in the final exam.

In the final exam, we will prepare a formula sheet and attach it with the exam. The formula sheet will also be posted in the course webpage before the final exam.

**Lecture Note 7 (CNC)**

- Types of NC systems
- Types of interpolations
- Types of part programming
- Coordinate system in NC machine. Letter names for each axis.
- All the CNC programming words in the lecture note (their function and how to use them)
- Know how to write a CNC program based on a given tool trajectory and know how to draw the tool trajectory based on a CNC program.

**Lecture Note 8 (Nontraditional machining (NTM))**

- When should NTM be used
- Common types and general principles of NTM
- Understand the general process, principle, tolerance, machining rate, benefit and application range (if they are given in the lecture note) for each and every NTM process introduced in the lecture note.
- Pay particular attention to the limits of each NTM. For exam, can EDM and ECM be used for non-conducting material?
- **We will NOT test the principles of laser generation (Slide 8-23)**
- Common types of laser-based manufacturing processes (you do not need to memorize the exact power density or fluences for each process, but you need to understand that different laser-based manufacturing processes may require different power densities).
- The general process, principle and benefit (if given in the lecture note) of the laser-based manufacturing processes introduced in the lecture note.
- What is additive manufacturing
- Common types of additive processes
- Process, principle and application range (if given in the lecture note) of each additive manufacturing process covered in the lecture note.

**Lecture Note 9 (microfabrication)**

- Advantage of microfabrication
- Microfabrication applications, and common microfabrication techniques
- The sequences of processing a p-n junction as shown on Slide 9-6.
- Common procedures in fabrication of microelectronic devices (Slide 9-7)
- Common types of semiconductor materials

- General steps in making a silicon wafer
- Purpose and types of oxidation
- Photoresist coating methods
- Principle of spin coating
- What is a negative photoresist and what is a positive photoresist
- Types of pattern generation methods and their pros and cons
- Principle of optical lithography
- What is etching? Types of etching methods.
- What is the ion implantation process. Be able to list a p-type dopant and an n-type dopant.
- **We will not test diffusion, metallization, bonding and packing processes in final exam (Slide 9-23 and 9-24).**
- Other common types of technologies in microfabrication
- Advantages of laser micromachining. Can list a few typical applications of laser micromachining
- Principle and benefits (if given in the lecture note) of laser-assisted micro machining, selective laser sintering, aerosol jet printing, laser dynamic forming.
- **We will NOT test contents on Slide 9-47 and 9-48**
- Principle of two-photon polymerization. How does it get high resolution?
- Application of laser surface texturing.
- Common structure characterizing techniques

**Lecture Note 10**

- Key element and procedure of soft lithography
- Applications, advantages and limit of soft lithography

**Lecture Note 11**

- Process variables in forming
- Effects of friction in forming
- Friction model
- Temperature range for hot working, warm working and cold working
- Effects of temperature on mechanical properties
- Advantages and disadvantages of cold working
- Preparation processes for cold working
- Types of forging.
- Forgeability and what it depends on
- Advantages of forging
- **You do NOT need to memorize the table on Slide 11-15**, but you should have a general common sense that aluminum alloys have better forgeability than tungsten alloys and heat increases forgeability.
- Features of press forging

- Understand all the calculation formulas given for upsetting, rolling, extrusion, and drawing processes. Know how to do related calculations.
- Understand rolling process and how grain structure changes
- Products from rolling. Tolerance and surface roughness from rolling. Note cold rolling typically produces smaller surface roughness and tolerances than hot rolling.
- Process and setup of extrusion.
- Types of extrusion. Differences between direct and indirect extrusion.
- Material for and characteristics of extrusion
- Lubrication method for hot extrusion
- Advantages and disadvantages of cold extrusion
- Types of drawing
- Maximum area reduction in drawing and typical drawing speed. Die material for drawing.
- Lubrication techniques in drawing

**Lecture note 12 (sheet metal forming)**

- Understand the shearing process, the punch and die clearance. Know how to calculate punch and die size fors punching and blanking processes, and how to calculate max punch force in shearing.
- Types of shearing
- Understand the bending process, bend radius (its relation with tensile reduction of area), spring back, bend allowance
- **You do NOT need to memorize the table on Slide 12-9**. But you need to know the meaning of the table if you are given the table and know how to do related analysis and calculations.
- Types of common bending operations
- Drawing force and holding force calculation in deep drawing. Limiting drawing ratio.
- Understand the process of spinning

**Lecture note 13 (powder metallurgy (PM) )**

- General procedure (cycle) for PM.
- Advantages and disadvantages of PM
- Powder production methods
- Important powder properties related to PM
- Compaction pressure and density non-uniformity issue, and its solution.
- Process of CIP and HIP
- Shrinkage in sintering, and effects of porosity on tensile strength, modulus and thermal conductivity
- Punch and die material
- Three stages in sintering, and common atmosphere
- Common secondary or finish operations

- Design consideration for PM

**Lecture Note 14**

- Characteristics of polymers
- Understand glass transition temperature
- Differences between thermoplastic and thermosetting polymer
- Temperature dependence of thermoplastics viscosity
- What is a composite?
- Mechanics of composite as introduced in the lecture note
- Process, system and variables of injection molding
- Different zones of the reciprocating screw in injection molding and their functions
- Function of injection mold
- Understand the reaction injection molding, extrusion, blow molding, extrusion blow molding, injection blow molding, and compression molding processes
- Understand the processing of reinforced plastics
- Characteristics of ceramics
- Types of ceramics processing techniques
- Common technologies for making metal matrix composites