Name : _____

Student ID # : _____

Material and Manufacturing Processes (M2794.001800)

Final Exam

December 11, 2014

Write your answers on the provided answer sheet (Blue Book). Please make sure to write your name and student ID on both the problem sheet and answer sheet, and submit both sheets.

1. [20 points] Determine whether the following statements are true or false. Mark T if it is true, otherwise F.

1) Stretch forming applies compressive stress on the workpiece, which decreases springback. ( )

2) Normally, polymers have larger coefficient of thermal expansion and thermal conductivity than metals. ( )

3) FIB (Focused Ion Beam) can be used both to cut workpiece material and to deposit materials on the workpiece. ( )

4) Burr forms in various cutting processes, and removing burrs requires additional processes. ( )

5) In polymer chain, crystalline region has higher ductility than amorphous region. ( )

6) Strength of fiber reinforced plastic (composite) can go higher than its fiber's bulk strength. ( )

7) Snap fit requires shorter joining time than bolt/nut joining. ( )

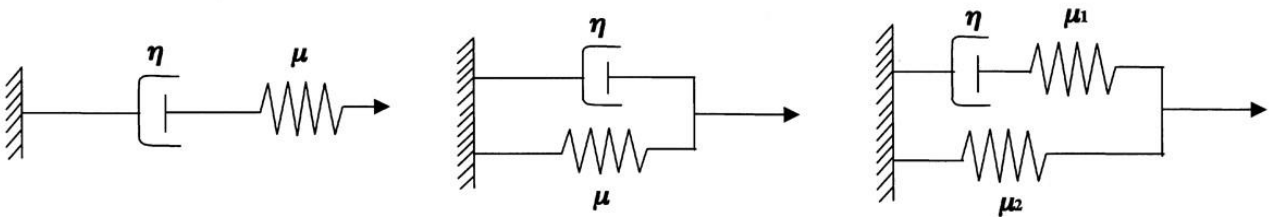
8) CMP (Chemical Mechanical Polishing) process is used in planarization of semiconductor manufacturing processes. ( )

9) Brazing melts both workpiece and filler material to join them. ( )

10) Selective Laser Sintering (SLS) does not require explicit support structure. ( )

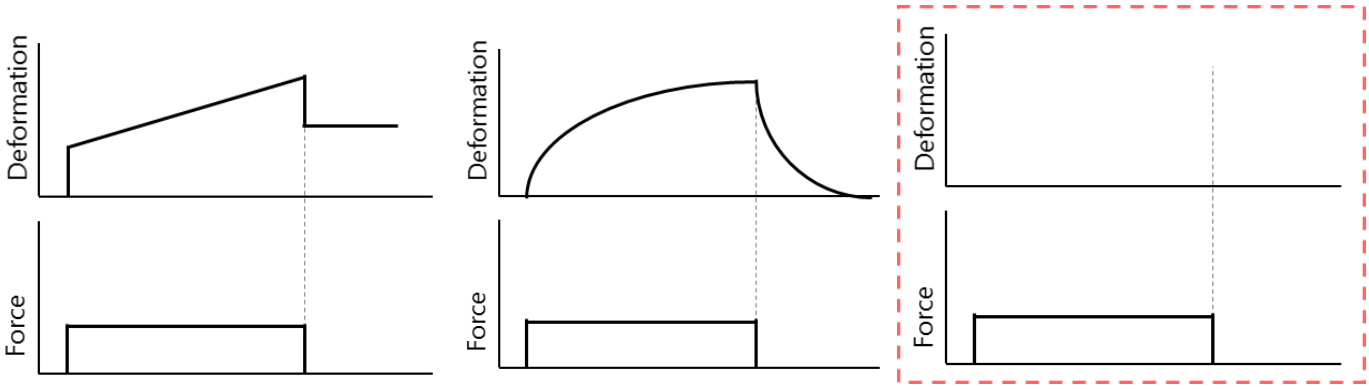
2. [20 points] Answer the following questions.

1) Spring-damper models are commonly used for analyzing viscoelastic behavior such as creep. Figures below are the examples: Maxwell model, Voigt model and Standard Linear Solid model.



Maxwell model　　Voigt model　　Standard Linear Solid model

In case where constant load is applied to a viscoelastic structure and released as figures below, complete the deformation graph of the material following Standard Linear Solid model. Assume both springs have the same spring constants.



Maxwell model　　Voigt model　　Standard Linear Solid model

2) Carefully observe given 'manufactured' parts for 30 seconds each, and guess its material, manufacturing processes including assembly. Explain why. (Real parts will be given)

3. [20 points] A component of fuel cell, so called bipolar plate, is fabricated by flat end milling process. The material is graphite and cutting tool diameter is 1 mm.

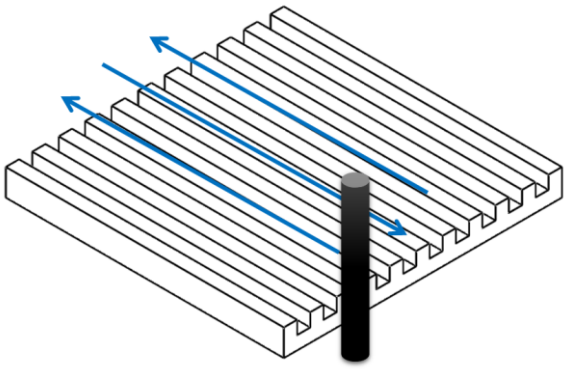


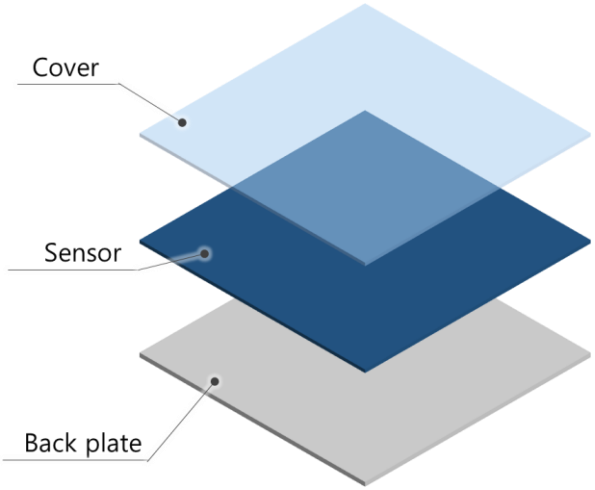
Figure 3 slot milling process

1) [10 points] Cutting conditions are as below. Calculate spindle speed [rpm], feed rate [mm/min], material removal rate [mm^3/sec].

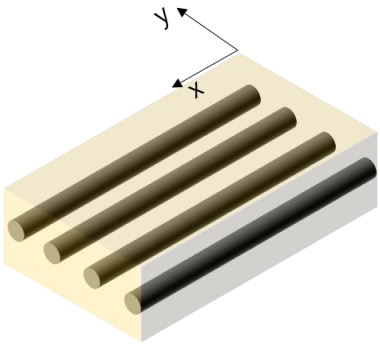
Tool diameter	1 mm
Feed per tooth	18 μm
Cutting speed	70 m/min
Number of cutting blades	2
Depth of cut	0.5 mm

2) [10 points] When exponent depending on cutting condition is 0.14 and constant is 170 in Taylor's tool life equation, draw tool life – cutting speed graph. And estimate tool life when cutting conditions are as above (problem 3-1).

4. [20 points] Some regions in North pole shows about 50˚C of annual temperature range (max-min). We're trying to collect weather data of such region by installing some sensors. Sensor modules consists of 3 layers: cover layer, sensor layer, and back plate.



1) Back plate will be fabricated in fiber reinforced composite. Calculate tensile modulus and coefficient of thermal expansion along x axis and y axis respectively.



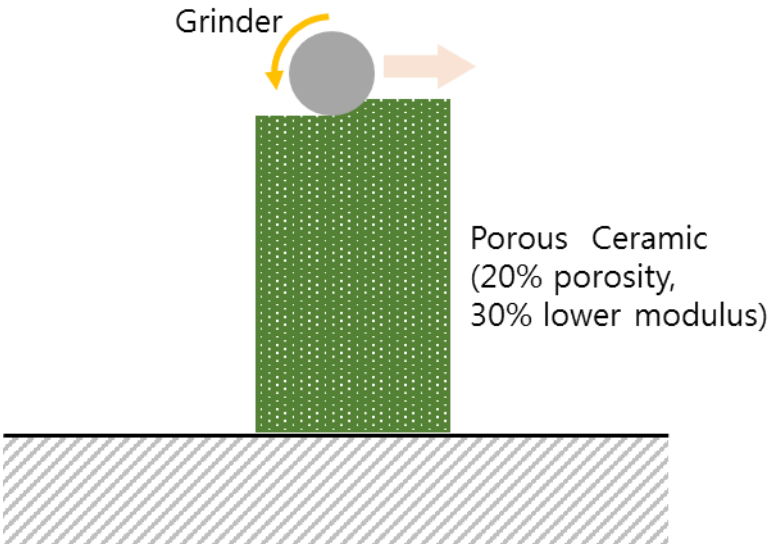
Property	Fiber	Matrix
Coefficient of thermal expansion (10^{-6}/°C)	-3	60
Tensile modulus (GPa)	120	3
Volume fraction	0.4	0.6

2) To avoid distortion of sensor by temperature difference, back plate's thermal expansion in one orientation should be 0. The back plate consists of total 10 layers of composite sheet (lamina) in 1). Every layers are either 0° or 90° along the desired orientation. How many 0˚ and 90˚ layers will be needed? (Ignore expansion along thickness direction and y axis)

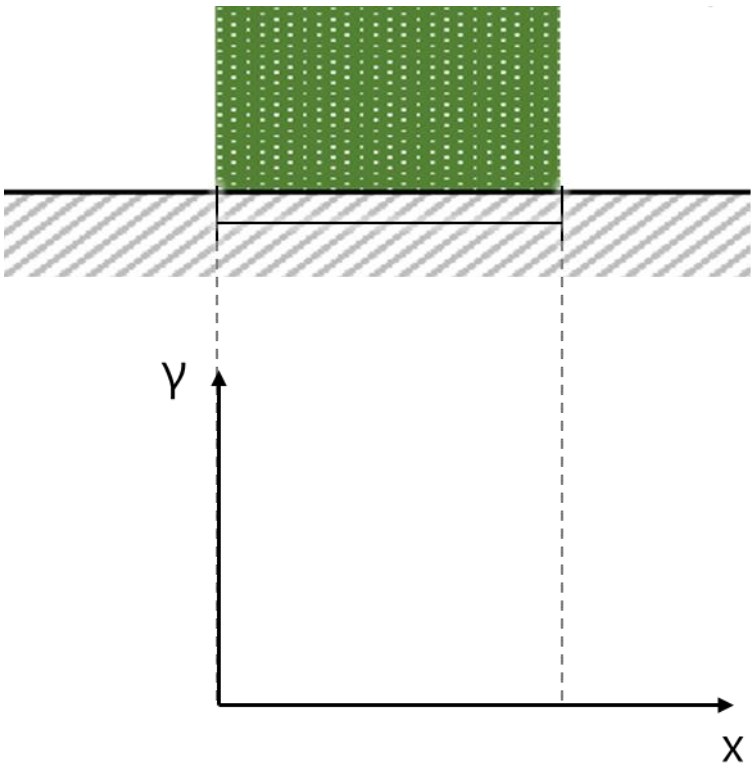
3) The cover layer should be fabricated to cope with uneven rapid temperature changes. Below table are the candidates of cover materials. Use idea of thermal shock resistance to decide which material is the most appropriate one for this cover.

Material	Fracture strength (σ_f)	Elastic modulus (E)	Thermal conductivity (k)	Coefficient of thermal expansion (α)
Glass	70Mpa	50Gpa	0.8W/mK	0.1E-5/˚C
Poly carbonate	60Mpa	2Gpa	0.2W/mK	7E-5/˚C
PMMA	50Mpa	3Gpa	0.2W/mK	5E-5/˚C
Quartz	50Mpa	70Gpa	1.5W/mK	0.5E-5/˚C

5. [20 points] Below figure shows a structure made by 'green' ceramic particles followed by planarization by grinding. The green part shows 20% of porosity and bonded to the metallic substrate.



1) When the grinding tool moves in constant speed and force in horizontal direction, draw overall shear stress distribution in horizontal direction on the bottom of the structure. Explain why.



2) When this green part is sintered at sintering temperature, what will happen to the porosity and strength. Explain why. (Assume: Young`s modulus of green ceramic and metallic substrate is same.)