Name :	
Student ID # :	

Material and Manufacturing Processes (M2794.001800) Midterm Exam October 28, 2014

Write answers on given Blue Book. This Question Sheet should be submitted with Blue Book, so write down your name and student ID on both of them. (Penalty will be applied when Question Sheet is not submitted)

- 1. Determine whether the following statements are true or false. Mark T or F [2 points each]
 - (a) Buckling occurs when compressive force is applied on thin material, in longitudinal direction. (
 - (b) If plastic deformation occurs in material by compression, it shows anisotropy, which makes smaller ductility in the loading direction than ductility in perpendicular to the loading direction. ()
 - (c) A structure made of single crystal has bigger grain size than that made of poly resulting in lower strength. ()
 - (d) Residual stress in material can be eliminated by annealing process or applying tensile strength over yield point. ()
 - (e) In casting process, chills can control cooling rate. ()
 - (f) In open-die forging process, barreling can be reduced by reducing friction between die and the workpiece. ()
 - (g) In rolling process, uniform thickness can be obtained when there is no friction between roll and the workpiece. ()
 - (h) Drawing is the process that applies compressive force on a material by pushing it through circular die. ()
 - (i) The phenomenon that compressive yield strength gets smaller than tensile yield strength when tensile and compressive deformations are applied in a sequence is called Bauschinger effect.
 - (j) Yield point elongation often makes surface defect on thin sheet metal. ()

- 2. Answer the following questions. [10 points each]
- (a) Figure 1 shows a design of one part without considering manufacturing yet.



Figure 1 part design for molding

When you want to create the above parts by Die casting, suggest proper mold shape and parting line. Plus, suggest 3 DFM (Design for manufacturing) factors of Die casting manufacturing process and explain why.

- (b) Figure 2-1 is a Pelton turbine blade used in micro hydro power generation. Turbine blade operates at room temperature and withstands the load caused by water from nozzle during 100 million cycles in use. Assume that the shape and applied load of Pelton turbine blade are simplified as shown in Figure 2-2. Trying to select a material that yield strength is larger than maximum stress, choose the appropriate material for each of the following conditions and explain why. Please refer to Ashby chart and failure data on the next pages.
- Case #1: Blade has lightweight and high strength. Hint: Use simplified free body diagram shown at Figure 2-2.
- Case #2: Blade has low cost and high strength. Hint: Use strength/C_{rp} ratio for comparing price.



Figure 2-1 Pelton turbine and its blade

Figure 2-2 Simplified free body diagram of blade





3. Koreans invented the first Metallic Printing Type in 1234 AD. Figure 3 shows actual usage of Metallic Printing and part of its manufacturing process.



Figure 3-1 Example of Metallic printing usage

Figure 3-2 Part of its manufacturing process

(a) From Figure 3-2, name which specific manufacturing process was used, and explain its manufacturing steps. [5 points]



FIgure 3-3 Incomplete phase diagram

(b) We are trying to fabricate Metallic Printing with Bi-Pb alloy, referring to its phase diagram (Figure 3-3). Complete the unfinished phase diagram referring to given conditions below. (draw and indicate each phase) [10 points]

- ✓ Melting point of pure Bi is 271℃.
- ✓ When 0.5 wt% Pb 99.5 wt% Bi is heated, solid and liquid phase start to coexist in 175℃.
- ✓ Eutectic point of Bi and ε is at 125℃, 45 wt% Pb 55 wt% Bi.
- ✓ When liquid 55 wt% Pb 45 wt% Bi is cooled, ε starts to appear at 150°C.
- ✓ In 187℃, 62 wt% Pb 38 wt% Bi has solid Bi, solid ε and also liquid phase.
- ✓ When liquid 80 wt% Pb 20 wt% Bi is cooled, solid Pb starts to appear at 250 °C.
- ✓ Melting point of pure Pb is 327℃.

* You can draw directly on this Question Sheet and submit.

(c) 1kg of 30 wt% Pb - 70 wt% Bi was used in the process. During cooing, [5 points]

- i. Calculate mass of proeutectic Bi in 126°C. (Assume that proeutectic appears on the boundary of phase change.)
- ii. Using same assumption with i , name every phase that exists in 124°C, and calculate mass of each phase.

4. Using closed-die forging process as shown in Figure 4, ten parts were manufactured.



Figure 4 Process of closed-die forging

(a) Write the name of \star in figure, explain its role. [7 points]

(b) As below table, surface roughness of 10 final parts in figure 4 was measured. Calculate C_p , C_{pk} about Ra of all 10 parts. Discuss whether the process is desirable or not when USL = 12, LSL = 8. [7 points]

Part number	Ra
# 1	12.56
# 2	13.84
# 3	7.56
# 4	8.87
# 5	10.11
# 6	15.50
# 7	11.54
# 8	9.81
# 9	7.75
# 10	7.10

(c) Write two kinds of surface treatment methods for improving surface hardness of the products. [6 points]

5. There are spherical and cylindrical containers with pressure P inside, which we want to use for making plastic deformation. Wall thickness t in much thinner than radius r, and pressure on the wall is uniform.



(a) When all the stresses are in elastic domain, estimate stresses on the very small volume of the wall, and draw Mohr circle of each container using the stresses. [10 points]

(b) If pressure P increases from 0, find out which container would yield first. Use Von Mises Criterion, and explain it by drawing graph. [10 points]

