注意：考試開始鈴響前，不得翻閱試題，並不得書寫、畫記、作答。

國立清華大學 110 學年度碩士班考試入學試題

系所班組別：工程與系統科學系
甲組

科 目 代 碼 ：3001

考 試 科 目 ：物理冶金

—作答注意事項—

1. 請核對答案卷（卡）上之准考證號、科目名稱是否正確。
2. 考試開始後，請於作答前先翻閱整份試題，是否有污損或試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。
3. 考生限在答案卷上標記「由此開始作答」區內作答，且不可書寫姓名、准考證號或與作答無關之其他文字或符號。
4. 答案卷用盡不得要求加頁。
5. 答案卷可用任何書寫工具作答，惟為方便閱卷辨識，請儘量使用藍色或黑色書寫；答案卡限用 2B 鉛筆畫記；如畫記不清（含未依範例畫記）致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。
6. 其他應考規則、違規處理及扣分方式，請自行詳閱准考證明上「**國立清華大學試場規則及違規處理辦法**」，無法因本試題封面作答注意事項中未列明而稱未知悉。

國立清華大學 110 學年度碩士班考試入學試題

系所班組別：工程與系統科學系碩士班 甲組(0530)

考試科目（代碼）：物理冶金 (3001)

 *請在【答案卷】作答

1. Fig. 1 shows a $(\bar{1}11)$ slip plane of fcc crystal containing an edge dislocation. (a) Write down the Burgers vector of the dislocation. (2%) (b) What is the direction of $[u_1v_1w_1]$. (3%) (c) Describe the position of the dislocation including direction of the dislocation line and the Burgers vector in Fig. 1. (5%) (d) In fcc metals, the dislocations are usually dissociated into an extended dislocation, containing two partial dislocations and a stacking fault. Fig. 2 shows an extended dislocation in fcc lattice. Describe the position of the partial dislocation including the direction of dislocation line and Burgers vectors. (5%) (e)The strength of an fcc metal can be increased by controlling the stacking fault energy. Discuss the strengthening mechanism. (5%)

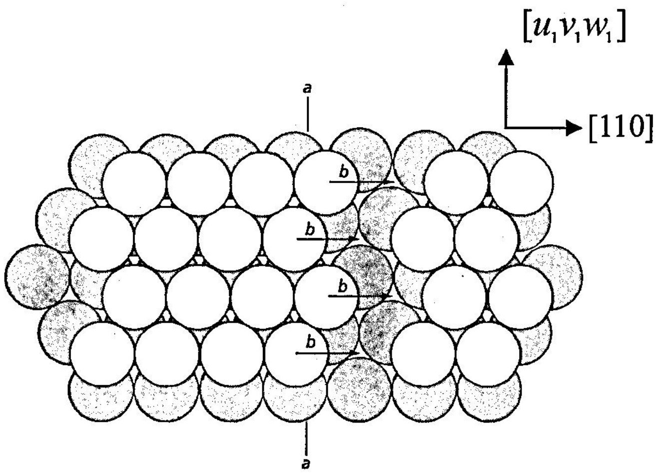


Fig. 1

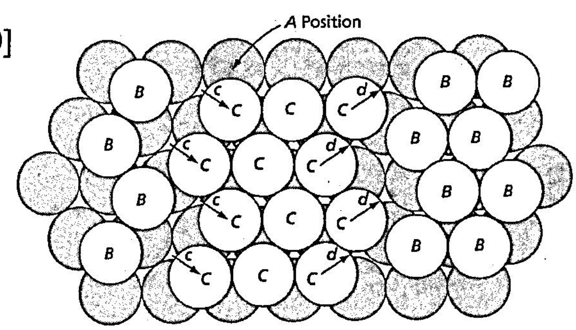


Fig. 2

2. Three different metal crystals, all of which are cubic (either FCC or BCC) are strained, and the orientation of the crystal is tracked. Each of them is strained in **compression**. In the stereographic projections below, the results of these tests are shown. (a) Identify whether you think the crystal is FCC or BCC (5%), and (b) **explain** briefly why in each case (15%).

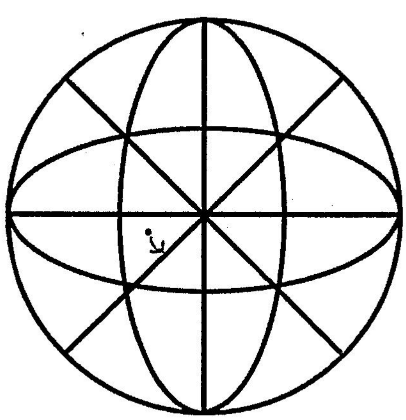


Fig. 3

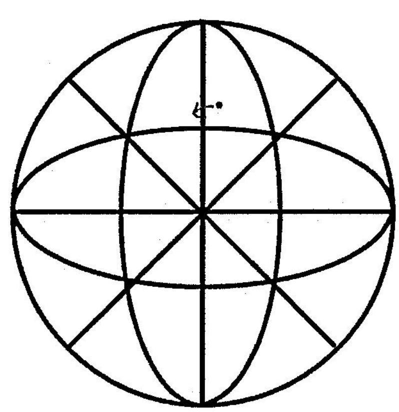


Fig. 4

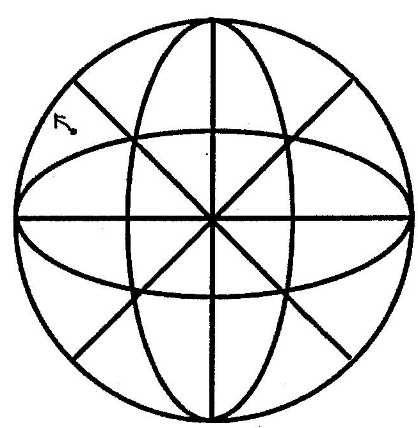


Fig. 5

3. (a) There is a condition for necking for a true stress-strain curve called Considère's criterion. Derive the Considère's criterion for a true stress-strain curve satisfied $\sigma = K\varepsilon^n$, where σ is the true stress, ε is the true strain, n is the strain hardening exponent, and K is the strength coefficient.(5%)

(b) Discuss why the strain hardening exponent decreases with increasing stacking fault energy, as shown in the table below (5%)

Metal	Stacking Fault Energy (mJ/m^2)	Strain-Hardening Coefficient	Slip Character
Stainless steel	<10	~0.45	Planar
Cu	~90	~0.3	Planar/wavy
Al	~250	~0.15	Wavy

(c)For fcc and bcc metals, there are different temperature dependence on the flow stress components, as shown in Figs. 6 and 7. Use the Considère's criterion to **explain** the reasons that cause this difference. (10%)

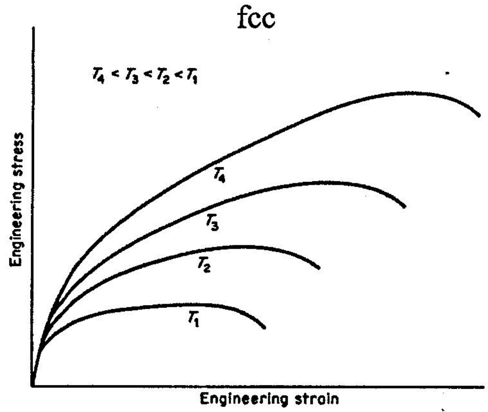


Fig. 6

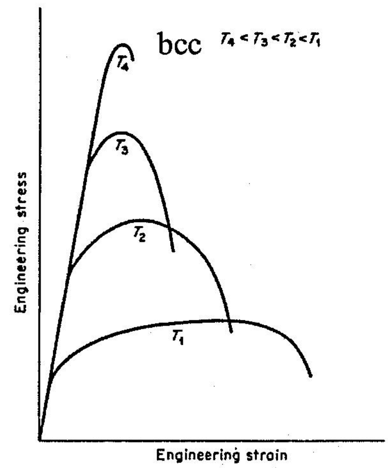


Fig. 7

4. For a eutectoid composition steel, the TTT diagram is shown schematically below

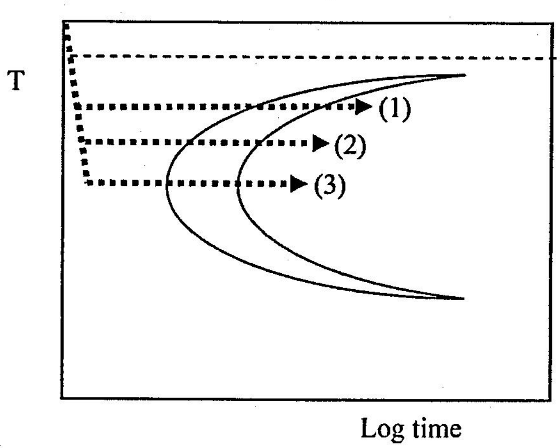


Fig. 8

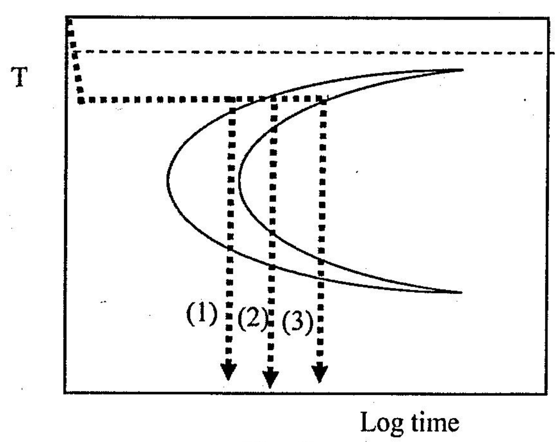
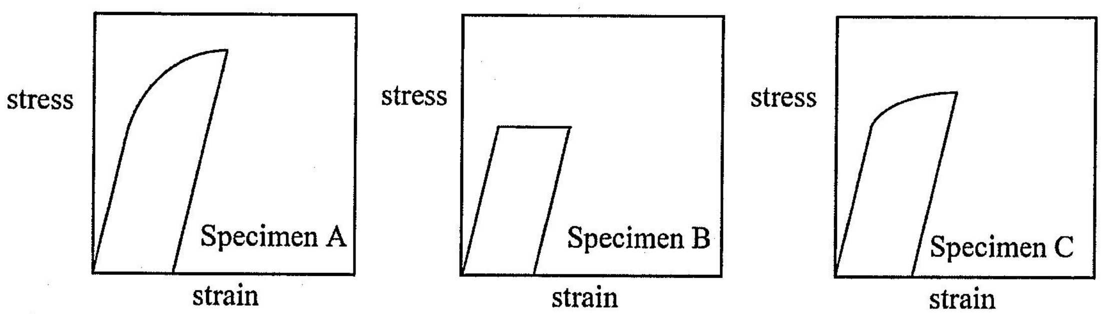


Fig. 9

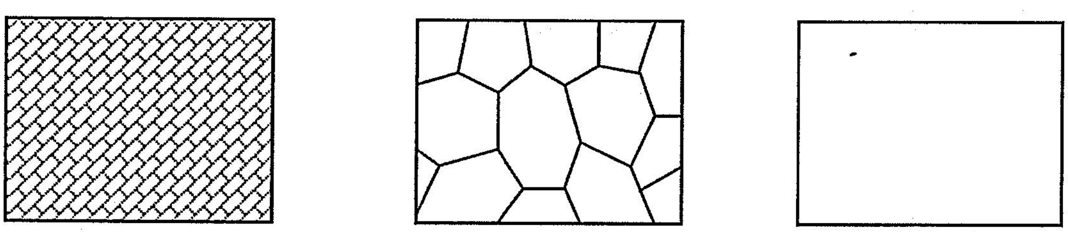
(a) Refer to Fig. 8 above, and consider the three temperature histories shown. If you are trying to design a steel that best takes advantage of dislocation interactions with a second phase (i.e., strength controlled by bowing), which path is best and why? (10%)

(b) Refer to Fig.9 above, and consider the three temperature histories shown. If you are trying to produce a microstructure that derives strength through load transfer without being brittle, which path is best and why? (10%)

5. An undergraduate student carried out his independent study on the deformation and annealing of **single crystals.** He had three identical specimens of the same metal, but which were cut with different crystal orientations. He carefully performed tensile tests to a fixed level of strain, and then unload them. He finds:



He then annealed the three specimens at the same temperature for the same amount of time. However, he forgot to label the three specimens. To identify the specimens, he polished the three specimens and performed metallography to look at the microstructure. Here was what he got:



Structure I　　　Structure II　　　Structure III

Your advisor asked you to help him to solve the problem. Based on the stress-strain curve and the microstructure of the three specimens, (a) sort out which post-annealing microstructure belongs to which sample, (5%) and (b) write a short explanation for your choices. (15%)