

注意: 請依照題目次序在答卷上作答

A. 機械材料 (50%)

一、(25%)

1. Answer the following questions regarding material's density (15%):

- (1). Offer an explanation as to why covalently bonded materials are generally less dense than ionically or metallically bonded ones. (5%)
- (2). Calculate the linear density of the [100] direction for body-centered cubic crystalline structure (BCC). (5%);
- (3) Calculate the planar density of the (110) plane for face-centered cubic crystalline structure (FCC). (5%).

2. Phosphorus is added to high-purity silicon to give a concentration of  $10^{23} \text{ m}^{-3}$  of charge carries at room temperature. (10%)

- (1) Is this material n-type or p-type? (5%)
- (2) Calculate the room-temperature conductivity of this material, assuming the electron and hole mobilities are the same as for the intrinsic material ( $0.14 \text{ m}^2/\text{V}\cdot\text{s}$ ). The absolute magnitude of the electrical charge on an electron is  $1.6 \times 10^{-19} \text{ C}$  (5%).

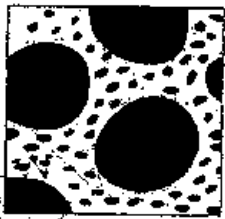
二、(25%)

1. A zinc single crystal is being pulled in tension with the normal to its basal plane (0001) at  $60^\circ$  to the tensile axis and the slip direction [1120] at  $40^\circ$  to the tensile axis.

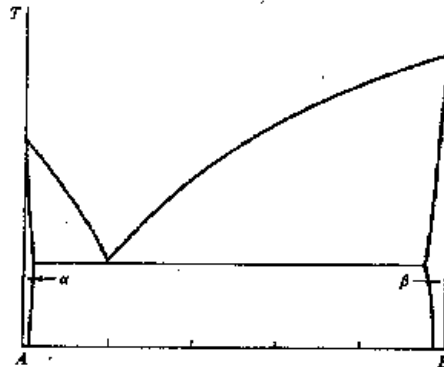
- (1) What is the resolved shear stress,  $\tau$ , acting in the slip direction when a tensile stress of  $0.690 \text{ MPa}$  ( $100 \text{ psi}$ ) is applied? (3%)
- (2) What tensile stress is necessary to reach the critical resolved shear stress,  $\tau_c$  of  $0.94 \text{ Mpa}$  ( $136 \text{ psi}$ )? (3%)

2. In a materials laboratory experiment, a student sketches a microstructure observed under an optical microscope.

The sketch appears as



The phase diagram for this alloy system is



- Determine (1) whether the black regions in the sketch represent  $\alpha$  or  $\beta$  phase (3%) and
- (2) the approximate alloy composition. (3%)

3. Compare precipitation hardening and the hardening of steel by quenching and tempering with regard to

- (1) The total heat treatment procedure. (5%)
- (2) The microstructure that develop. (4%)
- (3) How the mechanical properties change during the several heat treatment stages. (4%)

# 國立中央大學九十學年度碩士班研究生入學試題卷

所別: 機械工程學系 乙組 科目: 機械材料及材料力學 共 2 頁 第 2 頁

## B. 材料力學

一、(25%)

1. A steel shaft and an aluminum tube are connected to a fixed support and to a rigid disk as shown in the cross section (Fig. 1). Knowing that the initial stresses are zero, determine the maximum torque  $T_0$  which may be applied to the disk if the allowable stresses are 120 MPa in the steel shaft and 70 MPa in the aluminum tube. Use  $G = 80$  GPa for steel and  $G = 27$  GPa for aluminum. (10%)

Fig. 1

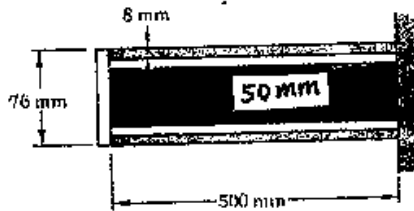
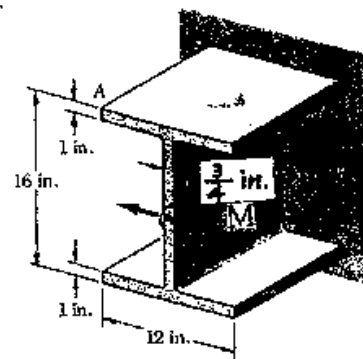


Fig. 2



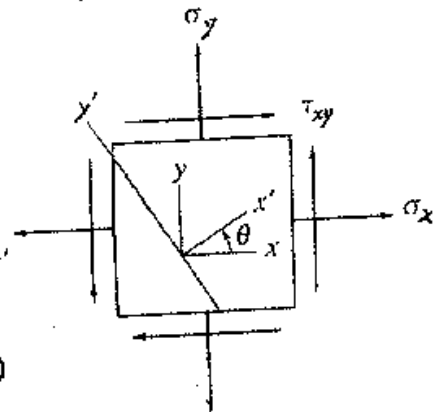
二、(25%)

- (1) By referring to the figure as shown for plane stress conditions, please derive the equations,

$$\sigma_{x'} = \frac{1}{2}(\sigma_x + \sigma_y) + \frac{1}{2}(\sigma_x - \sigma_y)\cos 2\theta + \tau_{xy} \sin 2\theta$$

$$\tau_{x'y'} = -\frac{1}{2}(\sigma_x - \sigma_y)\sin 2\theta + \tau_{xy} \cos 2\theta$$

where the normal stress and shear stress acting on the  $x'$  plane are given in terms of rotation  $\theta$  and the stresses  $\sigma_x$ ,  $\sigma_y$ , and  $\tau_{xy}$  acting on the  $x$  and  $y$  planes. (8%)



- (2) Using the result of the previous problem, (a) please express the principal stresses and the orientation of the planes of these principal stresses in terms of the stresses  $\sigma_x$ ,  $\sigma_y$ , and  $\tau_{xy}$  (8%), and (b) express the maximum shear stress in terms of the stresses  $\sigma_x$ ,  $\sigma_y$ , and  $\tau_{xy}$  (4%). Show the details of your work.

- (3) Schematically construct a Mohr's circle with assuming that all stresses  $\sigma_x$ ,  $\sigma_y$ , and  $\tau_{xy}$  are greater than zero and  $\sigma_x > \sigma_y$ . (5%)

