A. 機械材料 (50%)

1. Magnesium (in hexagonal close-packed crystal structure) and aluminum (in face-centered cubic crystal structure) are two popular materials in the manufacture of cell phones due to their low density.
   (a) Even though magnesium is lighter, it is more difficult to fabricate (especially in forming). Briefly interpret the difficulty of fabrication for magnesium based on the crystal structure. (5%)
   (b) For corrosion concern, magnesium alloy belongs to active galvanic series than aluminum alloy. Which one is more resistant to corrosion? (5%)

2. (a) What is the IT (isothermal transformation) diagram for a plain carbon steel? (5%)
   (b) What is the CCT (continuous cooling transformation) diagram? (5%)
   (c) What is the difference between them? (5%).

3. Fig. 1 is the tin-gold phase diagram, for which only single-phase regions are labeled.
   (a) Specify temperature-composition points at which all eutectic, eutectoids, peritectics, and congruent phase transformations occur. (6%)
   (b) Also, for each, write the reaction upon cooling. (9%)

4. For the 40 wt.% Sn- 60 wt.% Pb alloy, phase diagram shown in Fig. 2, calculate the relative amount of each phase present in terms of mass fraction at 150°C (5%).

5. When making hardness measurements, what will be the effect of making an indentation very close to a preexisting indentation? Why? (5%)
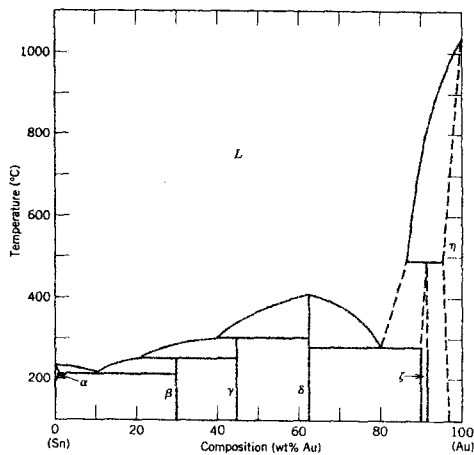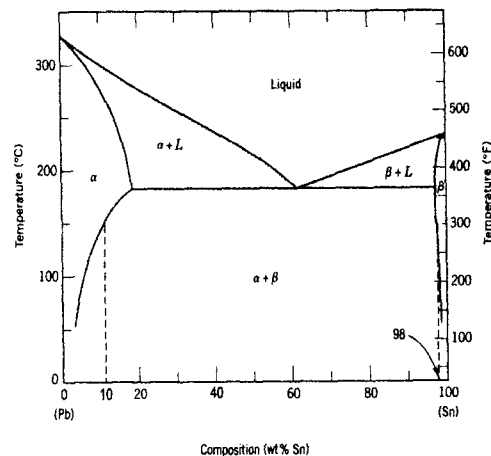

Fig. 1

Fig. 2

B. 材料力學 (50%)

1. (5%) By referring to the Fig. 3 where Mohr's circle is shown for plane stress, derive the equations for the transformation of plane stress

$$\sigma_{x'} = \sigma_x \cos^2 \theta + \sigma_y \sin^2 \theta + 2\tau_{xy} \sin\theta\cos\theta$$

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

Note that 2θ is the angle between points $X(\sigma_x, -\tau_{xy})$ and $X'(\sigma_{x'}, -\tau_{x'y'})$ counted counterclockwise along the circle.

注意：背面有試題

2. (10%) Draw the shear-force and bending-moment diagrams for the beam and loading shown in Fig. 4. (Show your work in detail)

3. (10%) A prismatic bar suspended from one end carries, in addition to its own weight, an axial load P_0, see the Fig. 5. Derive the strain energy U stored in the bar, that is,

$$U = \frac{\gamma^2 A L^3}{6} + \frac{\gamma P_0 L^2}{2E} + \frac{P_0^2 L}{2AE}$$

where A is the cross-sectional area of the bar, E and γ the Young's modulus and the specific weight of the material, respectively.
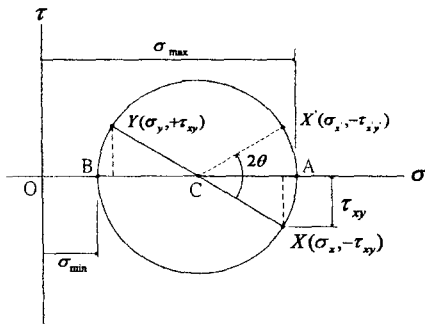

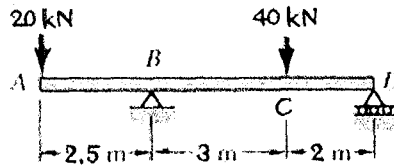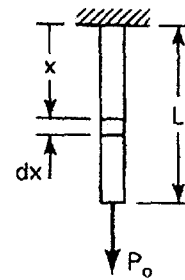Fig. 3   Fig. 4   Fig. 5

4. (10%) A hollow circular shaft and a solid circular shaft of the same material are to be designed to transmit the same torque T with the same maximum shear stress. If the inner radius of the hollow shaft is 0.85 times the outer radius, find: (a) the ratio of the outer diameter of the hollow shaft to the diameter of the solid shaft, and (b) the ratio of the weight of the hollow shaft to the weight of the solid shaft.

5. (15%) A projecting arm in a mechanical device is modeled as a cantilever beam AB (see Fig. 6). The arm is loaded at the free end by a force $P = 900$ N. The cross section has the dimensions shown in the figure. If the length L is 0.15 m, what are the maximum normal stress σ_{max} and the maximum shear stress τ_{max} due to the load P?
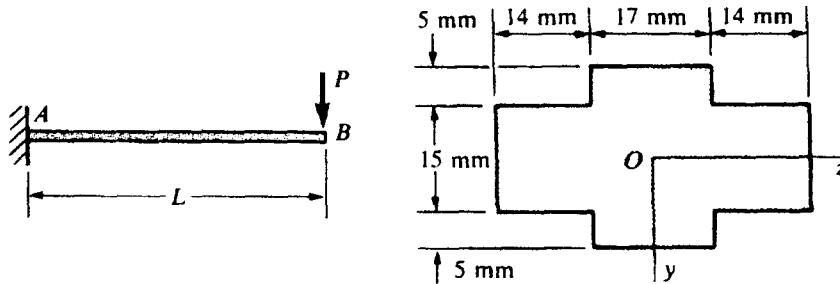

Fig. 6

注意：背面有試題