國 立 清 華 大 學 命 題 紙

99 學年度 動力機械工程學系丙組(固體與奈微米力學組)碩士班入學考試

科目 材料力學 科目代碼 1001 共 3 頁，第 1 頁 *請在【答案卷卡】作答

1. (15%) The pipe shown in Fig. 1 is stuck in the ground so that when it is pulled upward the frictional force along its length varies linearly from zero at B to f_{max} (force/length) at C. Determine the initial force P required to pull the pipe out and the pipe's associated elongation just before it starts to slip. The pipe has a length L, cross-sectional area A, and the material from which it is made has a modulus of elasticity E.

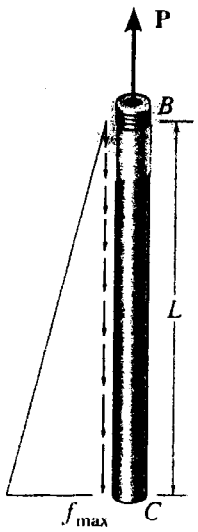

Fig. 1

2. (15%) A steel (shear modulus G = 80 GPa) tube with an inside diameter of 100 mm and an outside diameter of 125 mm is encased in a Monel (shear modulus G = 65 GPa) tube with an inside diameter of 125 mm and an outside diameter of 175 mm as shown in Fig. 2. The tubes are connected at the ends to form a composite shaft. The shaft is subjected to a torque of 15 kN · m. Determine

   (a) the maximum shearing stress in each material.

   (b) the angle of twist in a 5-m length.

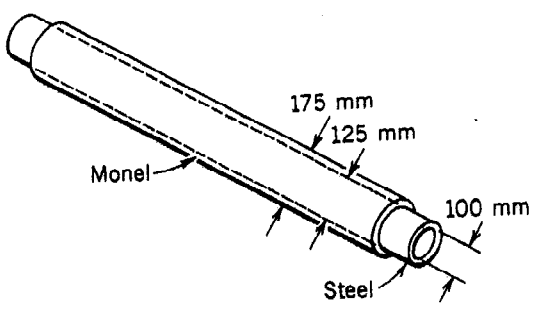

Fig. 2

3. (20%) The strain rosette shown in Fig. 3 was used to obtain the following strain data at a point on the free surface of an aluminum alloy (Young's modulus E = 70 GPa and Poisson's ratio ν = 0.33) machine part:

$$\varepsilon_a = 2000\mu, \quad \varepsilon_b = 1500\mu, \quad \varepsilon_c = -1300\mu$$

Determine the principal stresses and the maximum shearing stress at the point by first computing the principal strains and the maximum shearing strain at the point and using these strains to compute the stresses.

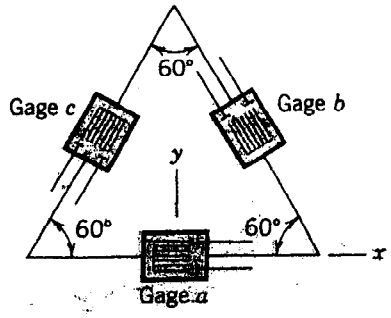

Fig. 3

4. (15%) A compressed-air tank having an inner diameter of 20 cm and a wall thickness of 1/4 cm is formed by welding two steel hemispheres (see Fig. 4 below).
   (a) If the allowable tensile stress in the steel is 4,000MPa, what is the maximum permissible air pressure p_a in the tank?
   (b) If the allowable shear stress in the steel is 6,000 MPa, what is the maximum permissible pressure p_b?

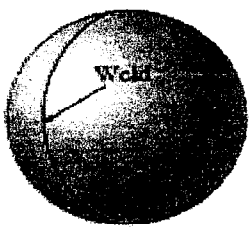

Fig. 4

5. (15%) Find the deflection *w* at the free end B of a cantilever beam ACB supporting a uniform load of intensity *q* acting over the right-hand half of the beam (see Fig. 5 below). (Note: The beam has length *L* and constant flexural rigidity *EI*.)

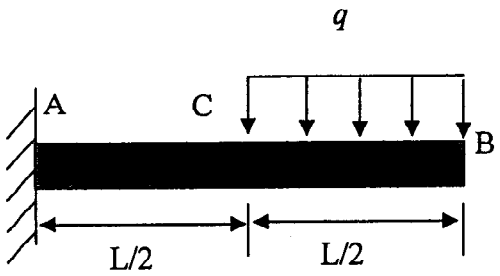

Fig. 5

6. (20%) The rotor shaft of a helicopter drives the rotor blades that provide the lifting force to support the helicopter in the air (see Fig. 6(a) below). As a consequence, the shaft is subjected to a combination of torsion and axial loading (see Figs. 6(b) and 6(c)). For a 100-mm diameter shaft transmitting a torque T = 3.4 kN · m and a tensile force P = 150 kN, determine the maximum tensile stress and maximum compressive stress in the shaft.

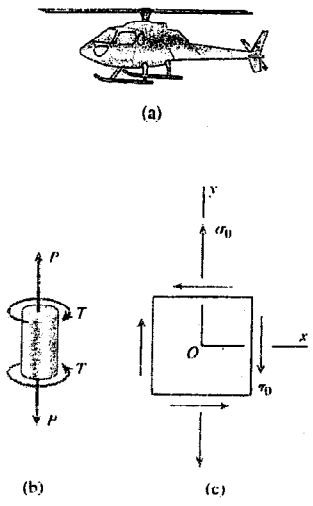

Fig. 6