CARLETON UNIVERSITY

FINAL
EXAMINATION
April 2009

Duration: 3 HOURS No. of Students: 70

Department Name & Course Number: **Mech. & Aero Engineering MECH 3700A**

Instructor(s): **A. Artemev**

AUTHORIZED MEMORANDA:

CALCULATORS ONLY

Students **MUST** count the number of pages in this examination question paper **before** beginning to write and report any discrepancy immediately to a proctor. This question paper has 5 pages.

This examination paper **MAY** be taken from the examination room.

Booklets

All questions have the same value. Answer all questions.

1. The maximum equilibrium solubility of hydrogen at a partial pressure of 1 *atm* in liquid magnesium is 26 cm^3 per 100 *g*. It falls to 18 cm^3 per 100 *g* upon solidification. The density of magnesium in both liquid and solid states is 1.74 g/cm^3.
   a) What would be the gas porosity (volume fraction of gas voids) in the Mg casting if the liquid metal were saturated with hydrogen at a partial pressure of 0.7 *atm* in the gas phase?
   b) What is the maximum partial pressure of hydrogen in contact with a liquid alloy at which no gas porosity is produced in casting?

2. Three cylinders were made of the same material. All cylinders had the same diameter of 3 *cm* and height of 4.2 *cm*. High temperature axial compression tests were performed on all cylinders at the same temperature. In all tests, a very efficient lubrication was used that completely prevented barreling effects. The first cylinder was subjected to the load of 1 *t* applied for the time interval of 1 *min*. The cylinder's height decreased from 4.2 *cm* to 2.15 *cm*. The second cylinder was subjected to the load of 1.5 *t* applied for the time interval of 0.5 *min*. Its height decreased from 4.2 *cm* to 2.05 *cm*. The third cylinder was subjected to the load of 0.75 *t* applied for the time interval of 1.5 *min*.
   a) Estimate by calculation the height of the third cylinder after the deformation if the material had the strain rate sensitivity exponent equal to 0.5.
   b) Comment briefly on the expected accuracy of the obtained height estimate.

3. A 30 *cm* long workpiece is stretched by force *F* as shown in Fig. 1 until $\alpha=15^{o}$. The original cross-section area of the workpiece is 2.5 cm^2. The material has a strain hardening curve described by:

$$\sigma = 360 \cdot \varepsilon^{0.42} \ MPa$$

Assume that the ends of the workpiece are pin support clamped (i.e., are free to rotate). Assume the free sliding of the load application point.

a). Find the total work done during stretching.

b). Find the maximum value of α that can be reached before necking begins.

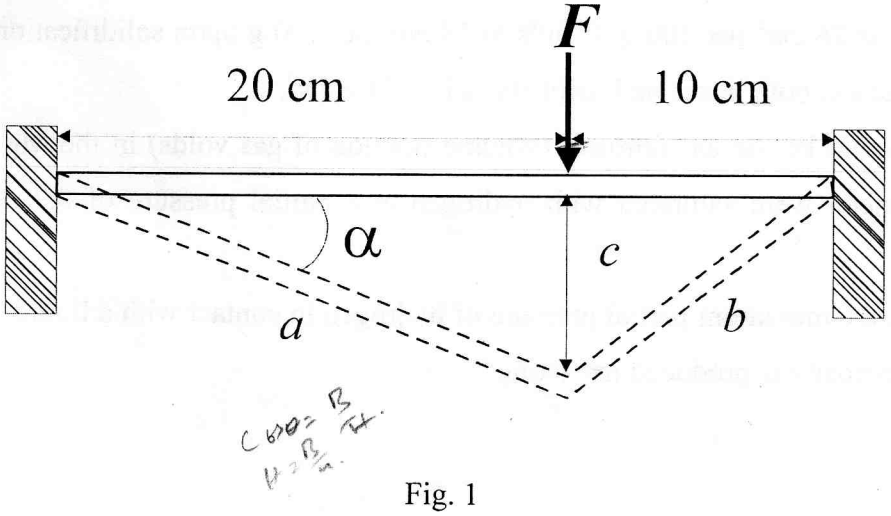

Fig. 1

4. A wire with the diameter of 2.5 mm has to be drawn to the diameter of 0.5 mm. The deformation properties of the wire were tested by a tensile test using a specimen with the initial gauge section length of 5 cm and the diameter of 2.5 mm. In this test the maximum tensile force equal to 2 kN was reached when the length of the gauge section increased by 15 mm.

   a) Estimate by calculations the number of drawing passes that would be necessary to obtain the required final diameter assuming that the drawing conditions are ideal without friction and redundant work effects, and the plasticity of the metal is fully restored between the passes using annealing in vacuum.

   b) For the die geometry shown in Fig. 2 and the friction coefficient equal to 0.1 estimate by calculation if drawing can be performed using the number of passes obtained in part a) in real conditions.

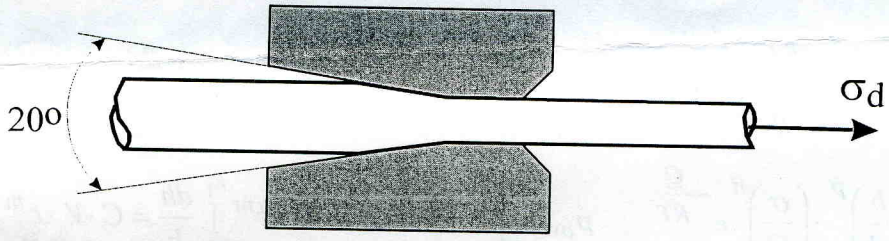

Fig. 2 Principle scheme of the drawing process and die geometry.

5. a) List three material characteristic that strongly affect the machinability of alloys.
   b) Describe briefly three different types of tool wear during the orthogonal cutting.
   c) Describe briefly the main advantages and disadvantages of the electron beam machining compared to conventional machining methods.

6. a) Describe briefly the main differences between the gas atomization and the soluble gas atomization processes.
   b) List three types of thermal welding processes.
   c) Briefly describe the main advantages of the ultrasonic welding process.