AML 883: Properties and selection of Engineering Materials
Minor II
23 March, 2009

Instructions

- Please answer all the questions.
- Please answer the questions in your own words; descriptive answers should not be more than five or six lines in length; copying sections of the textbook onto your answer booklet will not fetch you any marks.
- For numerical examples, please give all the steps; explain all the symbols; give the answers in proper units.
- For data that is needed (but not part of the question), use your textbook; when you do take values from the textbook, put the page number of the textbook from which you took the data in brackets next to the value.
- The maximum points are 200.
- **Question 1 – 20 points**

  A bronze statue weighing four tonnes with a base of area 0.8 mm^2 is placed on a granite museum floor. The yield strength of the bronze is 240 MPa. What is the true area of contact, A_r, between the base and the floor?
- **Question 2 – 40 points**

  You notice that the ceramic coffee mugs get too hot to hold about 10 seconds after pouring the hot coffee. The wall thickness of the cup is 2 mm. What, approximately, are the thermal diffusivity and conductivity of the cup material? If the cup were made of a metal with a thermal diffusivity of 2×10^{-5} m^2s^{-1}, how long could you hold it?
- **Question 3 – 40 points**

  The resistivity of copper (FCC, lattice parameter 3.61 Å, density 8960 kg m^{-3}) is 1.7×10^{-8} ohm m. The resistivity of aluminium (FCC, lattice parameter 4.05 Å, density 2700 kg m^{-3}) is 2.8×10^{-8} ohm m.

Assuming that both in copper and in aluminium, each atom contributes one electron to the free electron density, calculate the mobilities of electrons in copper and in aluminium.

- **Question 4 – 15 points**

  Roughly 50% of all cork that is harvested in Portugal ends up as cork dust, a worthless by-product. As a materials expert, you are approached by an entrepreneur who has the idea of making useful products out of cork dust by compacting it and heating it, using microwave heating. The loss factor L of cork is 0.21. The entrepreneur reckons he needs a power density P of at least 2 kW m^{-3} for the process to be economic. If the maximum field E is limited to 10^2 V/m, what frequency f of microwaves will be needed?

- **Question 5 – 25 points**

  Given cold-drawn high-strength steel (of strength 1700 MPa and resistivity 22 $\mu\Omega$), and cold drawn high-conductivity copper (of strength 300 MPa and resistivity 1.7 $\mu\Omega$ cm), which are used at the ratio 70% copper strands to 30% steel strands to make a power transmission cable, calculate the effective resistivity and strength of the cable.

- **Question 6 – 30 points**

  A coil of 50 turns and length 10 mm carries a current of 0.01 Amps. The core of the coil is made of a material which is non-magnetic. What is the magnetization M and the induction B?

- **Question 7 – 20 points**

  The absorption coefficient of polyethylene for optical frequencies is 86.6 m^{-1}. How thick a slab of polyethylene is required to reduce the transmitted light intensity to one-half of its initial value?

- **Question 8 – 10 points**

  The refractive index of Germanium is 4 as opposed to that of diamond, which is 2.42. Since reflectance increases with increasing refractive index, Germanium has better reflectance than diamond (See. Fig. 16.6 on p. 375 of your textbook). Still Germanium cannot be (and, is not) used in costume jewelry. State at least one important criterion that Germanium fails to satisfy.