

EXAMINATION 2013 / 2014

AHOLIADAU 2013 / 2014

EXAM

FACULTY OF APPLIED DESIGN AND ENGINEERING

NAME OF COURSE/PROGRAMME: MSc in Non-destructive Testing & Evaluation

YEAR OR LEVEL: Level 7

NAME OF MODULE/UNIT/EXAM PAPER: Electrical and Magnetic Methods

MODULE NO:

DATE OF EXAMINATION:

EXAMINATION TIMES:

START TIME: 10.00am

FINISH TIME: 12.00 am

TIME ALLOWED: 2hrs

INSTRUCTIONS TO CANDIDATES:

Answer all questions.

Where necessary refer to the magnetisation material curves provided.

Question 1. Total Marks - 12

- a) Using Ampere's law and assuming a uniform current density show that the magnetic field within a current carrying conductor with a circular cross section can be given as:

$$B = \frac{\mu J r}{2}$$

(6 marks)

- b) A magnetic particle inspection is to be carried out on a nickel-iron alloy component with a circular cross-section of diameter 20mm and length of 100mm. The required level of flux density is 1.2T. Using the direct current method calculate the necessary supply current.

(6 marks)

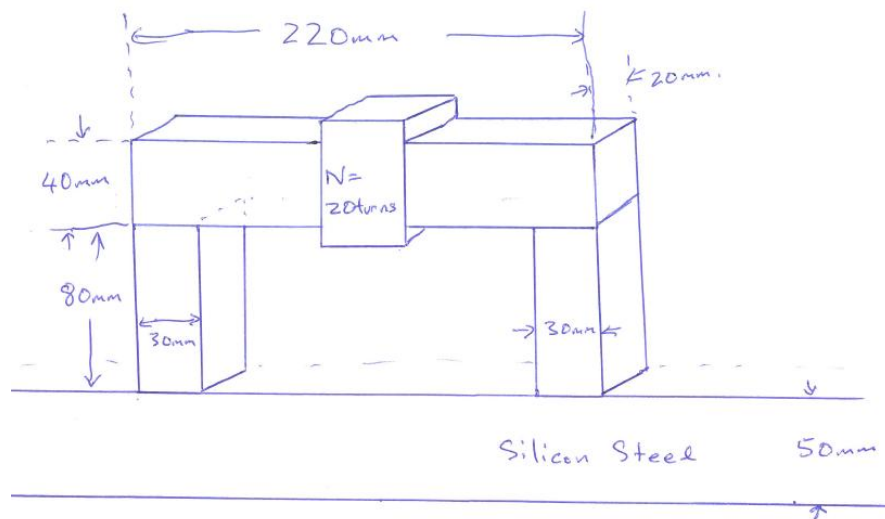
Question 2. Total Marks - 14

- a) With reference to magnetic flux leakage testing, discuss the importance and methods of demagnetization of a ferromagnetic component.

(6 marks)

- b) Using the cast steel electromagnetic yoke as illustrated in the figure below, determine the current required to achieve a flux density in the silicon steel component of 0.9T. Note: The yoke is in direct contact with the component.

(8 marks)



Question 3. **Total Marks - 26**

a) Using Ampere's law show that

- i) the magnetic flux density in the centre of a tightly wound solenoid with a non-conducting core can be given by:

$$B = \frac{\mu_0 Ni}{h}$$

(10 marks)

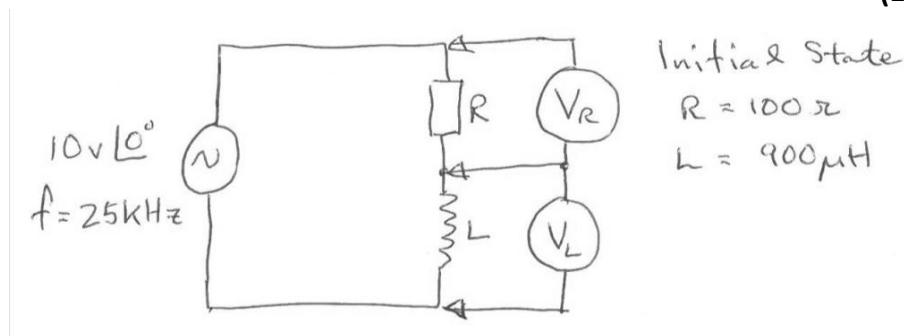
- ii) and its inductance using Faraday's law can then be shown to be:

$$L = \frac{N^2 \mu_0 \pi R^2}{h}$$

(6 marks)

b) The following circuit is used to determine and display the impedance variations in a conventional eddy current system. When the eddy current probe (L) is brought close to a conducting surface its inductance value increases to 1mH. Determine the measure voltages, V_R and V_L for the initial and final values and illustrate how this is displayed on a complex impedance diagram.

(10 marks)

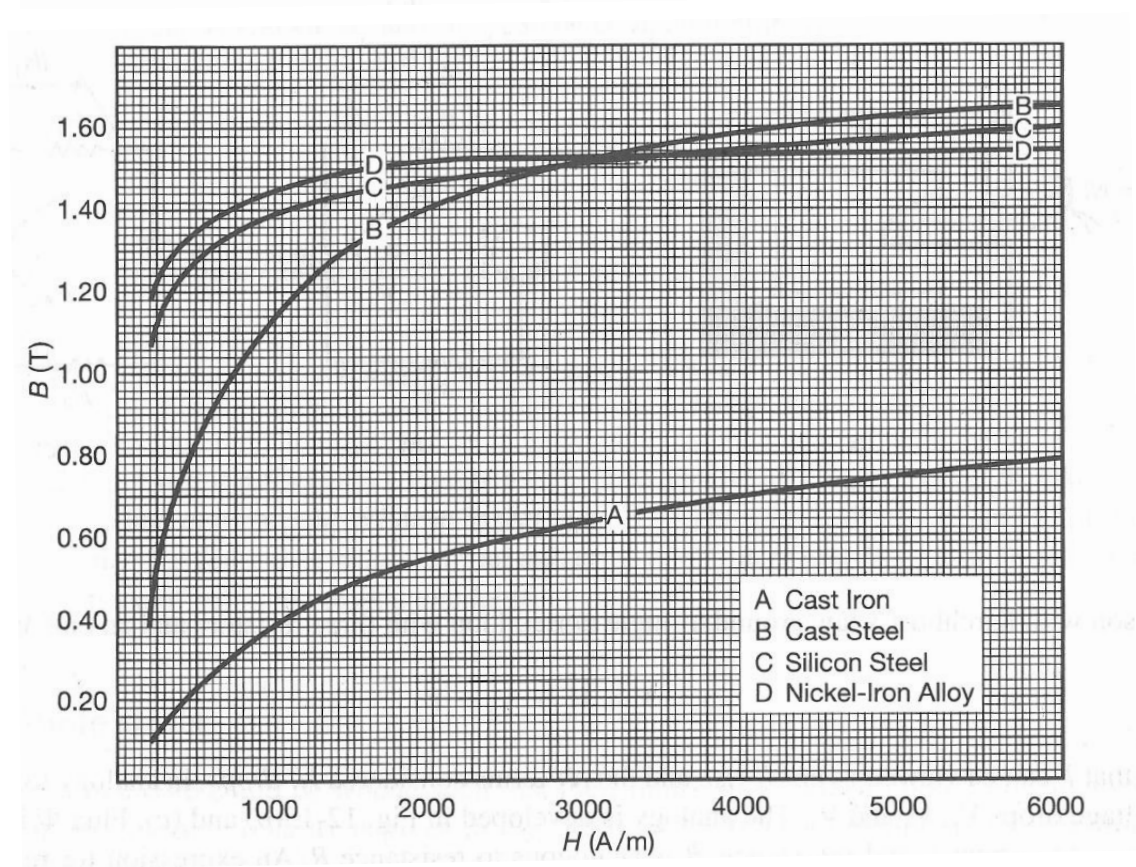
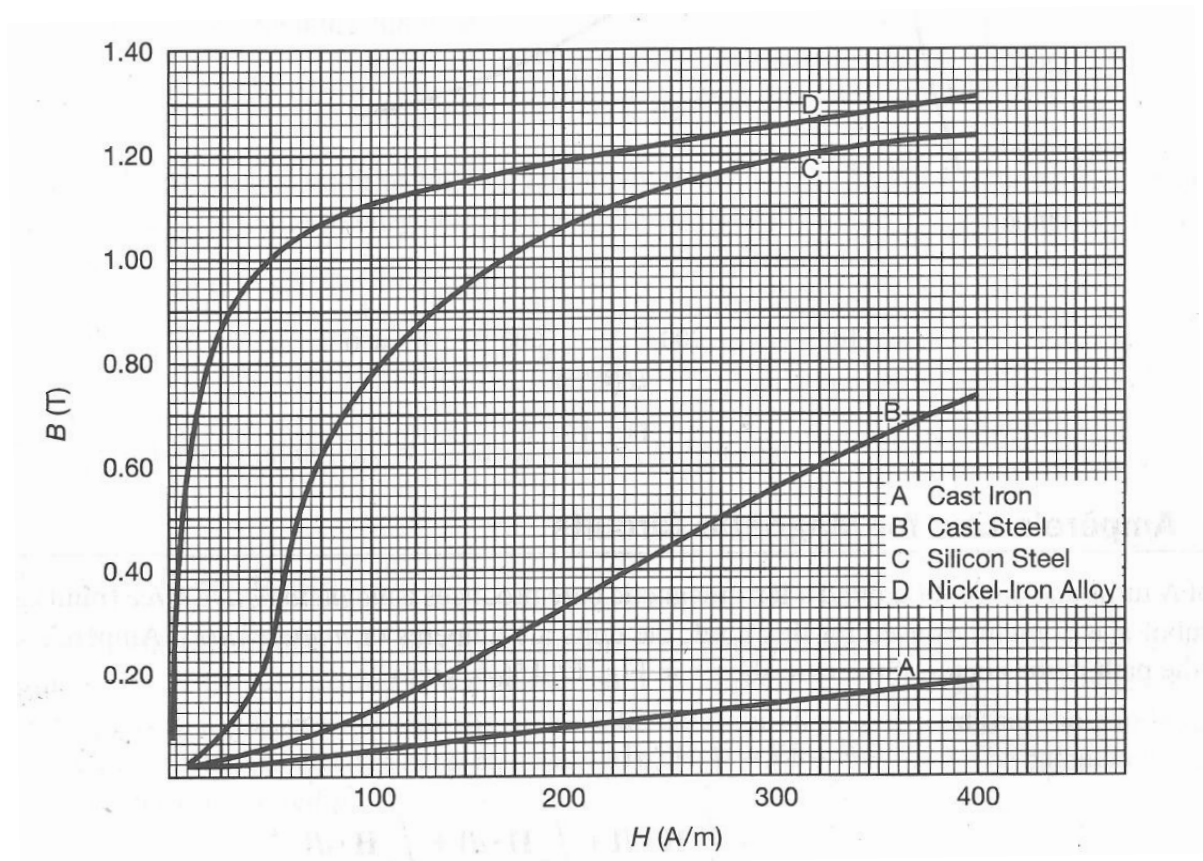


Question 4. **Total Marks - 8**

An eddy current test coil is used to inspect a copper component 1mm in thickness. Assuming 0.5mm as the standard depth of penetration required and that the conductivity of copper is 98.6 %IACS:

- i) Calculate the required test frequency. **(2)**
 ii) What would be the maximum phase difference between the induced near and far surface eddy currents? **(2)**

If we were to increase the test frequency by an order of 2, what would the effects be regarding the eddy current depth of penetration and near and far surface phase differences? **(4)**



General Formula and Constants

$$X_L = 2\pi fL$$

$$Z = \sqrt{R^2 + X_L^2}$$

$$\tan \theta = \frac{X_L}{R}$$

$$\delta_{mm} = \frac{661}{\sqrt{f\mu_r\sigma}}$$

$$\theta = \frac{x}{\delta} \times 57.3$$

$$B = \mu H$$

$$\mu_r = \frac{\mu}{\mu_o}$$

$$\mu_o = 4\pi \times 10^{-7}$$

Current Loop Centre Flux Density

$$B = \frac{\mu_r \mu_o I}{2R}$$

Solenoid Centre Flux Density

$$B = \mu n I$$

$$n = \frac{N}{h}$$

Magnetic Circuit Equations

$$\mu_o \iint J \cdot \partial s = \oint \vec{B} \cdot \vec{\partial l} \quad J = \int I \cdot \partial A$$

$$V_L = -L \frac{\partial I}{\partial t} \quad V_L = -N \frac{\partial \Phi}{\partial t}$$

$$mmf = H \cdot l \quad R_m = \frac{l}{\mu A} \quad F_m = N \cdot I \quad R_m = \frac{mmf}{\Phi} \quad B = \frac{\Phi}{A}$$