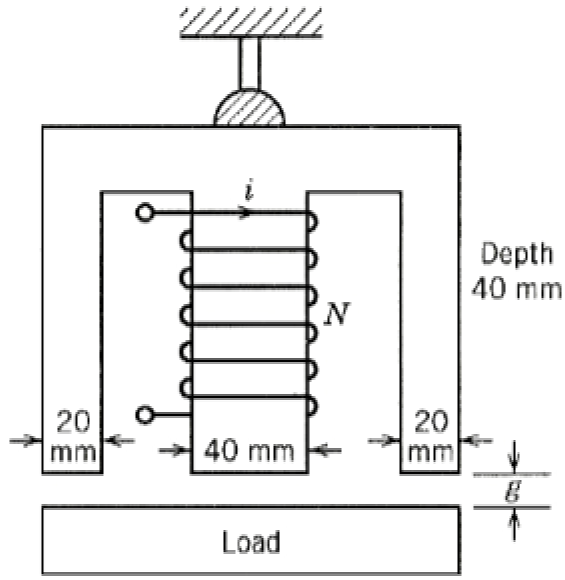
Question 1

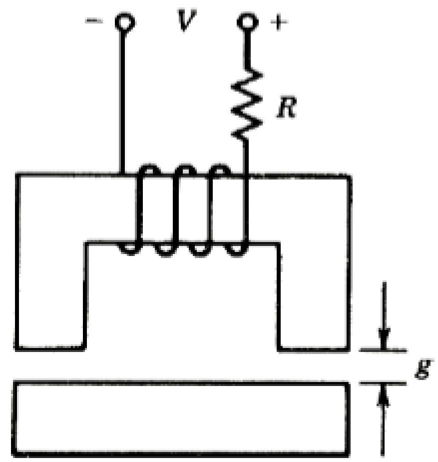



An electromagnet lift system is shown in the figure above. The coil has 2500 turns. The flux density in the air gap is 1.25T. Assume that the core material is ideal.

a) For an air gap, $g$ = 10mm
   i. Determine the coil current
   ii. Determine the energy stored in the magnetic system
   iii. Determine the force on the load (sheet of steel)
   iv. Determine the mass of the load (use acceleration due to gravity = 9.81m/s$^2$)

b) If the air gap is 2mmm determine the coil current to lift the load.

Question 2



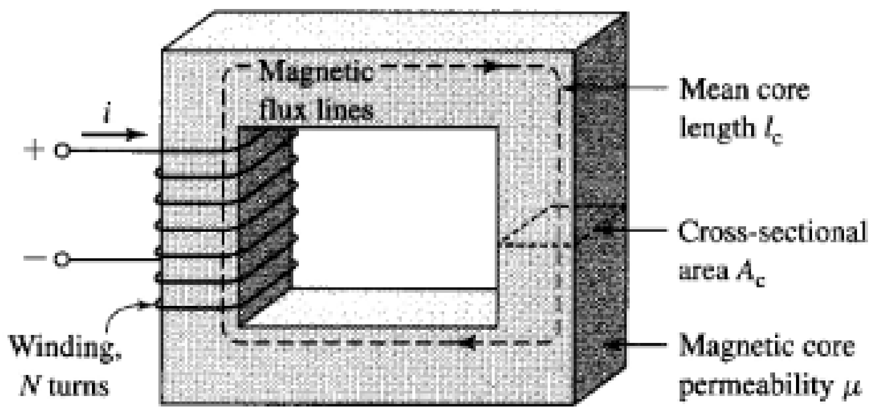

The electromagnet shown in the figure above can be used to lift a sheet of steel. The coil has 400 turns and a resistance of 5 ohms. The reluctance of the magnetic material is negligible. The magnetic core has a square cross section of 5cm by 5 cm. When the sheet of steel is fitted to the electromagnet, air gaps, each of length $g = 1$mm, separate them. An average force of 550 newtons is required to lift the sheet of steel.

a) For the DC supply,
   i. Determine the DC source voltage.
   ii. Determine the energy stored in the magnetic field.

b) For an AC supply at 60Hz, determine the AC source voltage.

# Magnetic Circuits

- Consider basic magnetic circuit




Assume all magnetic field is confined inside the core

Define Magnetic Flux

$$\Phi = \int_S \mathbf{B} \cdot \mathbf{da} = B_c A_c \quad [Wb]$$

Flux is always continuous

Consider mmf $F = Ni = H_c l_c = \frac{B_c l_c}{\mu} = \Phi \frac{l_c}{\mu A_c} = \Phi \Re_c$

Define Reluctance (of the given magnetic path) $\boxed{\Re_c = \frac{l_c}{\mu A_c}}$ $\left[\frac{A}{Wb}\right]$

Defines properties of magnetic core (or path)

Recall Inductance

$$\boxed{L = \frac{\lambda}{i} = \frac{N \cdot \Phi}{i} = \frac{N \cdot N \cdot i}{i \cdot \Re_c} = \frac{N^2}{\Re_c}}$$

Defines properties of magnetic core and the coils wound on it

# Energy & Co-Energy Coupling in Field

Consider a state of the system

$$i = i_a \qquad \lambda = \lambda_a \qquad \lambda = L_m(x)i$$

Energy going in coupling field

$$W_f = \int i d\lambda$$

Co-Energy associated with this state

$$W_c = \int \lambda di$$

Energy and Co-Energy Balance

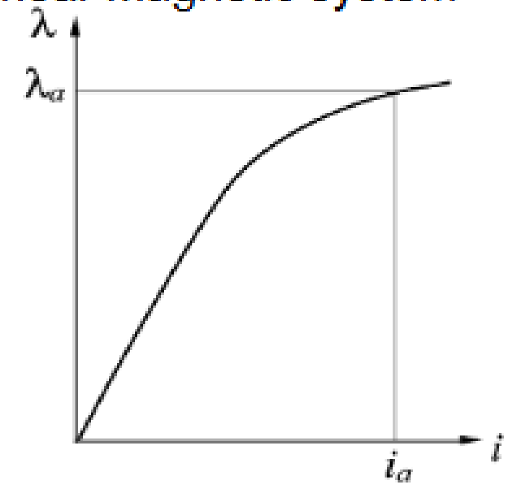
$$\lambda i = W_f + W_c$$

For magnetically linear systems

$$W_f = W_c = \frac{1}{2}\lambda i = \frac{1}{2}Li^2$$

Coupling Field is Conservative – The stored energy does not depend on the history of electromechanical variables, it depends only on their final state/values

Non-linear magnetic system




Magnetically linear system