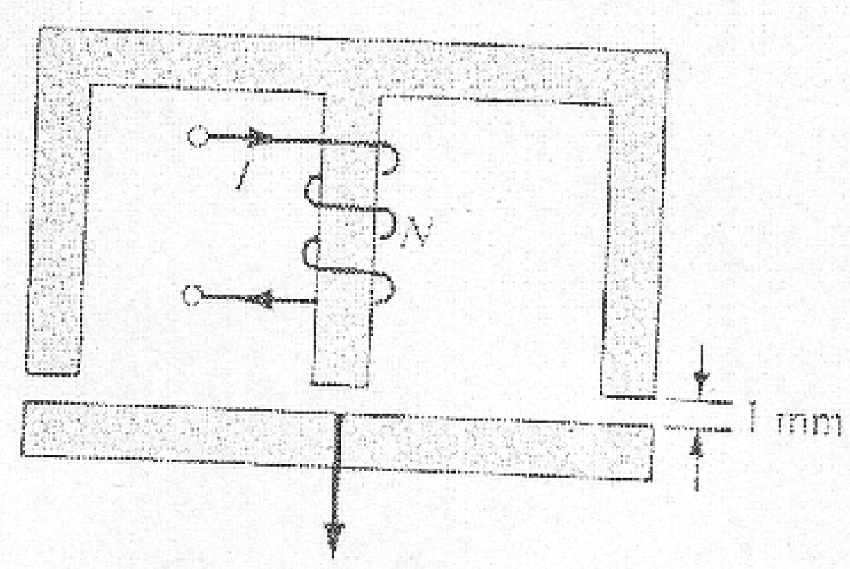
ELECTROMAGNETICS-II SECOND MIDTERM EXAM

- Time: 90 minutes
- Two pages of formula sheet can be used in the exam.
- No problem or example problem solution can be written on the formula sheet.

Dr. Salih FADIL **May 03, 2011**

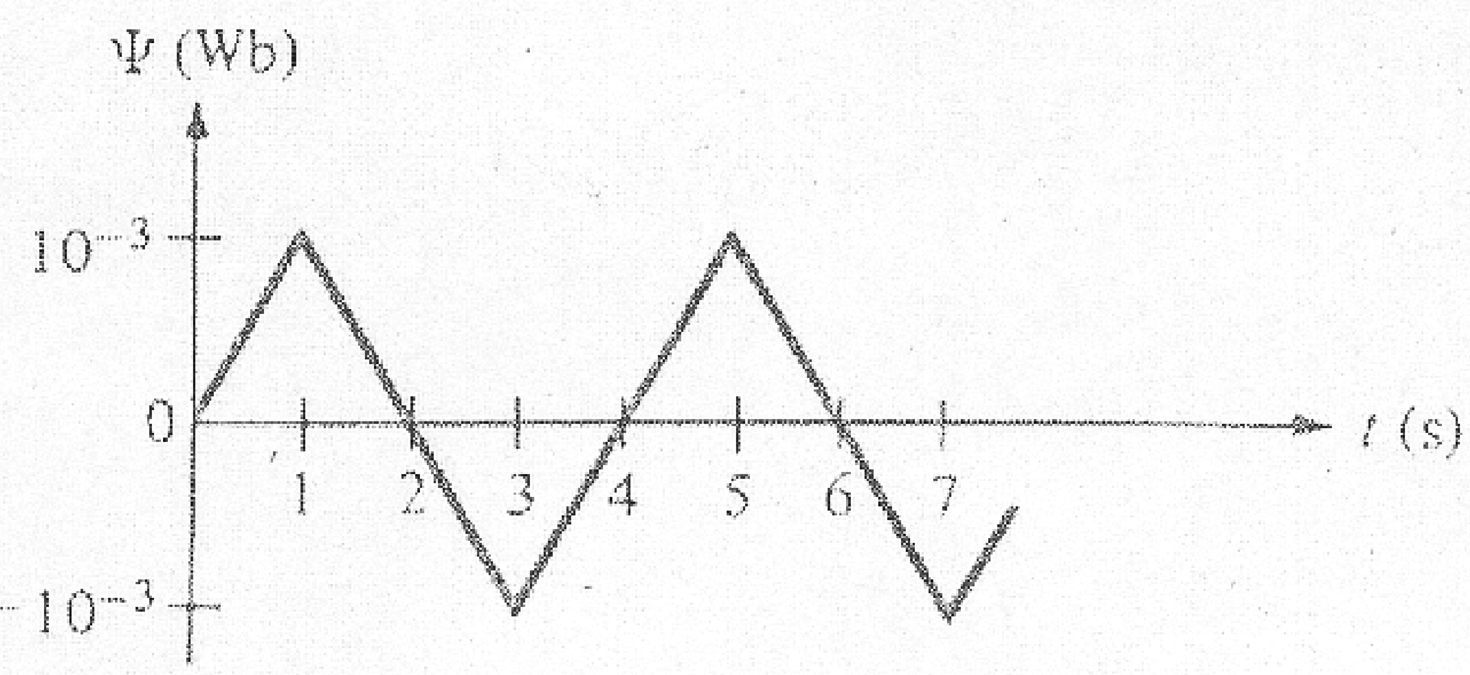
#1) A section of an electromagnet with a plate below it carrying a load is shown in the figure. The electromagnet has a contact area of 300 cm^2 per pole with the middle pole having a winding 2000 turns with $I = 1A$. Calculate the maximum mass which can be lifted. Assume that the μ of the core and the plate is infinite.



#2) The flux shown in the figure links 100 turns of a coil

a) Calculate the induced emf at $t = 0,\ \frac{1}{2},\ 2s$

b) Sketch the induced emf for $0 \le t \le 6s$.



#3) Given that $\vec{H}_1 = 10\vec{a}_x + 50\vec{a}_y - 20\vec{a}_z$ A/m in region $z \ge 0$ consisting of free space. Determine $\vec{B}_2$ in region $z \le 0$ consisting of material with $\mu = 6\mu_0$ if the interface carries current $60\vec{a}_y$ A/m.

GOOD LUCK...☺

ELECTROMAGNETICS - II FINAL EXAM
SOLUTION MANUAL

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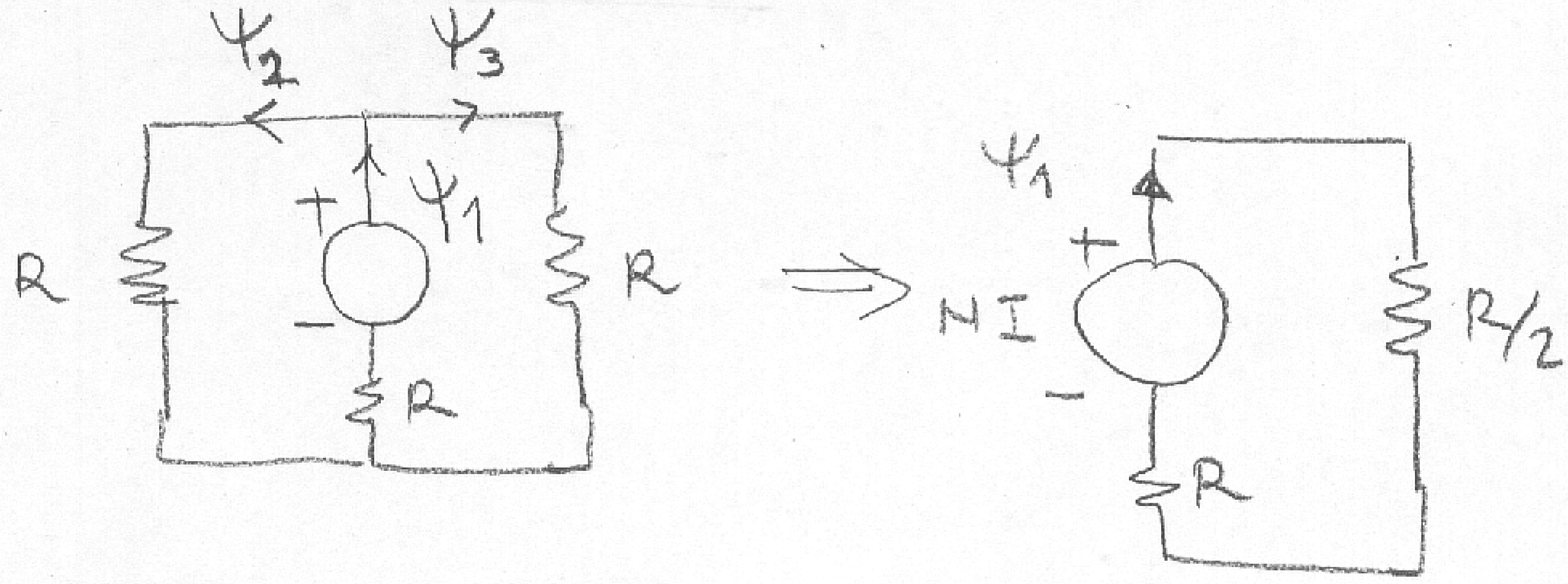
#1)



$$R = \frac{X}{\mu_0 S}$$

$$\Psi_1 = \frac{NI}{\frac{3R}{2}} = \frac{2NI}{3R} \qquad \Psi_2 = \Psi_3 = \Psi_1 \frac{R}{2R} = \frac{NI}{3R}$$

$$B_1 = \frac{2NI}{3RS} \qquad B_2 = B_3 = \frac{NI}{3RS}$$

$$f_{total} = \frac{B_1^2 S}{2\mu_0} + \frac{B_2^2 S}{2\mu_0} 2 = \frac{\frac{4(NI)^2}{9R^2S^2} S}{2\mu_0} + 2 \frac{\frac{(NI)^2 S}{9R^2 S^2}}{2\mu_0}$$

$$= \frac{4(NI)^2}{9R^2 S\, 2\mu_0} + \frac{(NI)^2}{9R^2 S \mu_0} = \frac{6(NI)^2}{18 \mu_0 R^2 S} = M.g$$

(2)   3

$$M = \frac{N^2 I^2}{3\mu_0 S \frac{X^2}{\mu_0^2 S^2} g} = \frac{N^2 I^2 \mu_0 S}{3 X^2 g} = \frac{(2000 \times 1)^2\, 4\pi 10^{-7}\, 300\, 10^{-4}}{3\, (10^{-3})^2 \cdot 9.81}$$

$$M = 5124 \text{ kg.}$$

#2) For $0 \le t \le 1$

$$\psi = 10^{-3} t \qquad 0 \le t \le 1$$

For $1 \le t \le 3$

$\psi = mt + n$;

$t = 1 \qquad 10^{-3} = m + n$

$t = 3 \qquad \pm 10^{-3} = \mp 3m \mp n$

$2\,10^{-3} = -2m \qquad m = -10^{-3}$

$10^{-3} = -10^{-3} + n \qquad n = 2\,10^{-3}$

$$\psi = -10^{-3} t + 2 \times 10^{-3} \qquad 1 \le t \le 3$$

For $3 \le t \le 5$

$\psi = mt + n$

$t = 3 \qquad -10^{-3} = 3m + n$

$t = 5 \qquad \mp 10^{-3} = \mp 5m \mp n$

$-2\,10^{-3} = -2m \qquad m = +10^{-3}$

$n = -10^{-3} - 3\,10^{-3} = -4\,10^{-3}$

$$\psi = 10^{-3} t - 4 \times 10^{-3} \qquad 3 \le t \le 5$$

$$v_{emf}(t) = -\frac{d\lambda}{dt} = -100\,10^{-3} = -10^{-1} = -0{,}1\ V \qquad 0 \le t \le 1$$

$v_{emf}(0) = -0{,}1$

$v_{emf}(1/2) = -0{,}1$

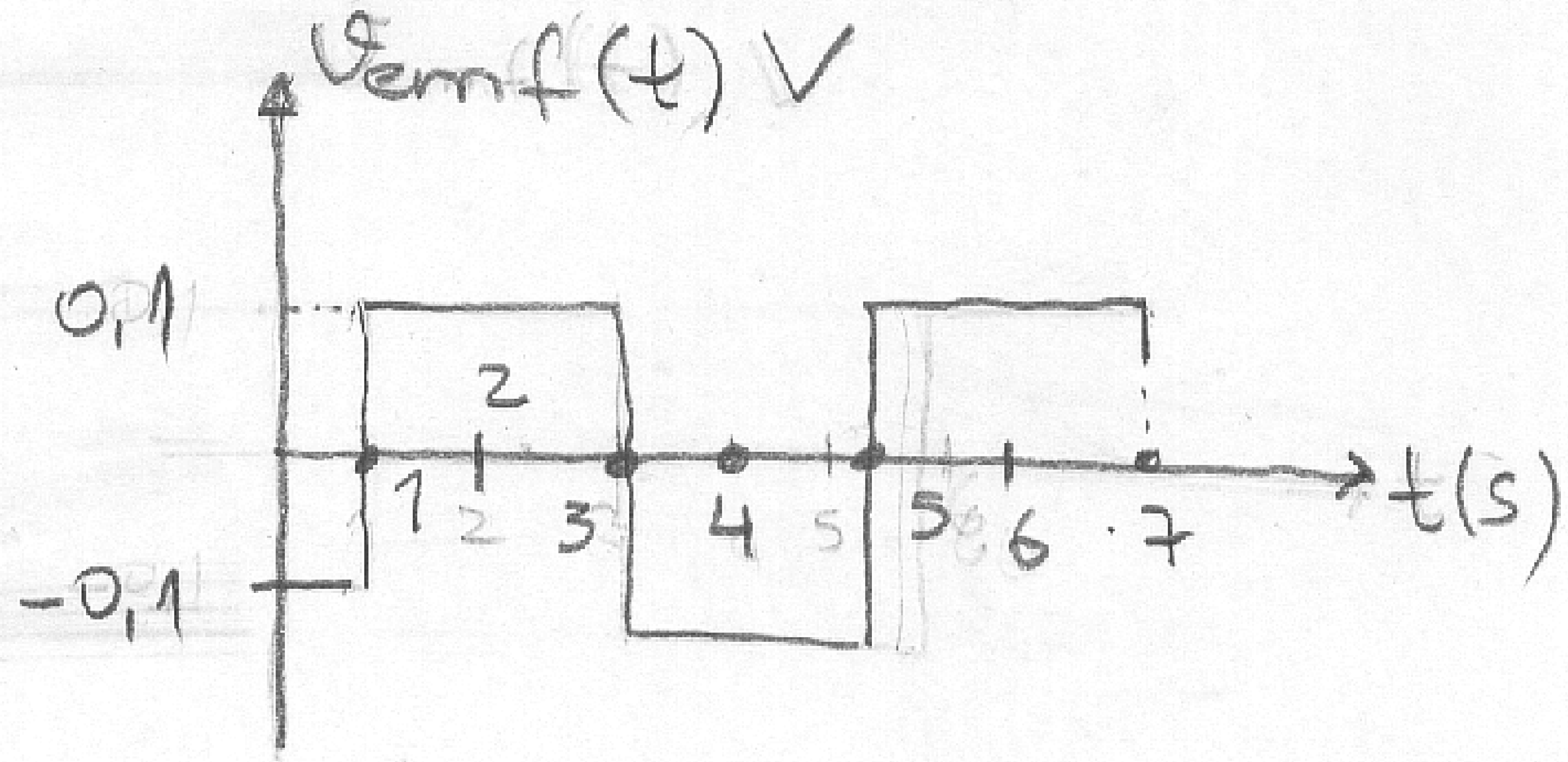
$$v_{emf} = -\frac{d\lambda}{dt} = -100\,(-10^{-3}) = +0{,}1\ V \quad \text{for at } t = 2s.$$

$v_{emf}(t) = -0{,}1\ V \qquad 0 \le t \le 1$

$v_{emf}(t) = 0{,}1\ V \qquad 1 \le t \le 3$

$v_{emf}(t) = -0.1\ V \qquad 3 \le t \le 5$

$v_{emf}(t) = +0{,}1\ V \qquad 5 \le t \le 7$

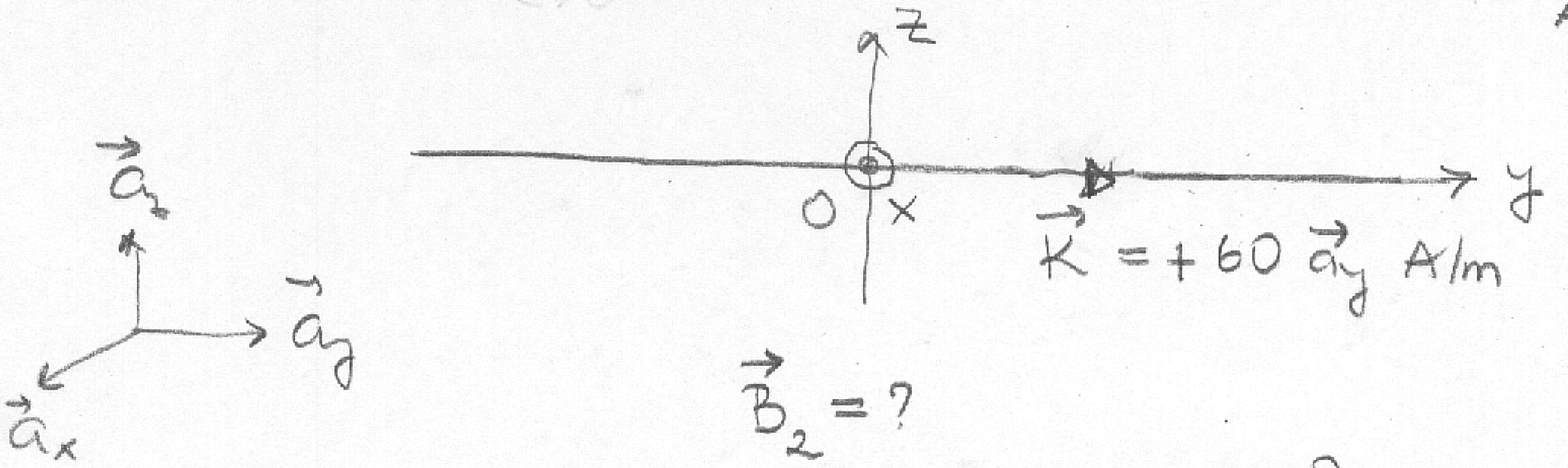


3)

Region – (1)

$\vec{H}_1 = 10\vec{a}_x + 50\vec{a}_y - 20\vec{a}_z$ $z \geq 0$ $\mu_1 = \mu_0$

A/m



$\vec{K} = +60\,\vec{a}_y$ A/m

$z \leq 0$ $\mu_2 = 6\mu_0$

$\vec{B}_2 = ?$

Region – (2)

$$\vec{B}_1 = \mu_0 (10\,\vec{a}_x + 50\,\vec{a}_y - 20\,\vec{a}_z) \; T$$

$$\vec{B}_{1n} = -20\mu_0 \vec{a}_z = \vec{B}_{2n} = \vec{B}_{2z}$$

$$\left(10\vec{a}_x + 50\,\vec{a}_y - 20\,\vec{a}_z - (H_{2x}\,\vec{a}_x + H_{2y}\,\vec{a}_y + H_{2z}\,\vec{a}_z)\right) \times \overset{-\vec{a}_z}{\widehat{\vec{a}_{n12}}} = \vec{K}$$

$$\left[(10 - H_{2x})\,\vec{a}_x + (50 - H_{2y})\,\vec{a}_y + (-20 - H_{2z})\,\vec{a}_z\right](-\vec{a}_z) = +60\,\vec{a}_y$$

$$(10 - H_{2x})\,\vec{a}_y + (50 - H_{2y})(-\vec{a}_x) = +60\,\vec{a}_y$$

$10 - H_{2x} = +60$ $\quad H_{2x} = -50 \rightarrow B_{2x} = -300\mu_0$

$50 - H_{2y} = 0$ $\quad H_{2y} = 50 \rightarrow B_{2y} = +300\mu_0$

$B_{2z} = -20\mu_0$

$$\vec{B}_2 = -300\mu_0\,\vec{a}_x + 300\mu_0\,\vec{a}_y - 20\mu_0\,\vec{a}_z \; T$$

$$\vec{B}_2 = -377\,\vec{a}_x + 377\,\vec{a}_y - 25.13\,\vec{a}_z \; \mu T$$