Problem 2

a) First the electron velocity is calculated from the current I:

$$I = jS = ne_0 vbc, \qquad v = \frac{I}{ne_0 bc} = 25\ \mathrm{m/s}\,.$$

The components of the electric field are obtained from the electron velocity. The component in the direction of the current is

$$E_{\parallel} = \frac{v}{\mu} = 3.2\ \mathrm{V/m}\,. \qquad (0.5\mathrm{p.})$$

The component of the electric field in the direction b is equal to the Lorentz force on the electron divided by its charge:

$$E_{\perp} = vB = 2.5\ \mathrm{V/m}\,. \qquad (1\mathrm{p.})$$

The magnitude of the electric field is

$$E = \sqrt{E_{\parallel}^2 + E_{\perp}^2} = 4.06\ \mathrm{V/m}\,. \qquad (0.5\mathrm{p.})$$

while its direction is shown in Fig. 5 (Note that the electron velocity is in the opposite direction with respect to the current.) (1.5 p.)

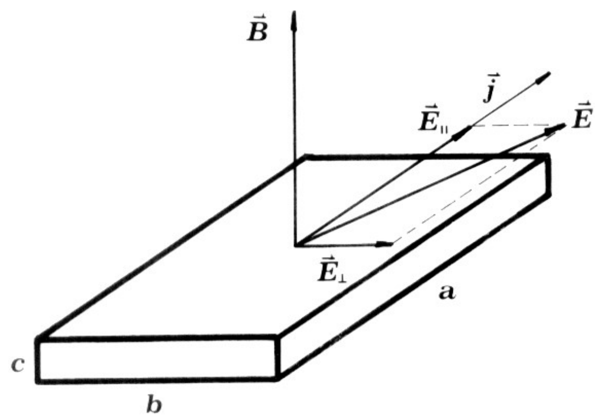

Fig. 5

b) The potential difference is

$$U_H = E_{\perp} b = 25\ \mathrm{mV} \qquad (1\mathrm{p.})$$

c) The potential difference U_H is now time dependent:

$$U_H = \frac{IBb}{ne_0bc} = \frac{I_0B_0}{ne_0c}\sin\omega t\sin(\omega t + \delta)\,.$$

The DC component of U_H is

$$\overline{U}_H = \frac{I_0B_0}{2ne_0c}\cos\delta\,. \qquad (3p.)$$

d) A possible experimental setup is-shown in Fig. 6

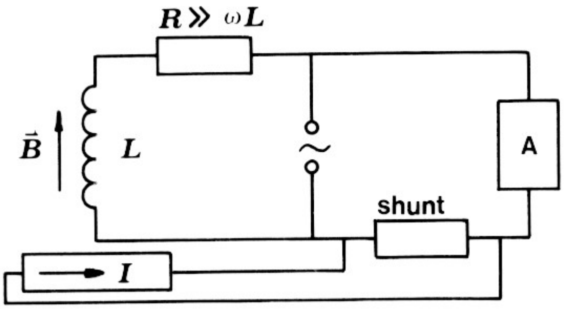

Fig. 6

(2 p.)