6 Some models of smart phones come with stylus pens for input, in addition to finger touch sensing. Fig. 6.1 shows a particular stylus pen which houses a wire coil of $N = 100$ turns and cross-sectional surface area $A = 3.0\ \text{mm}^2$. Beneath the screen of the smart phone lies a rectangular grid of wire coils, which are subject to an alternating voltage.

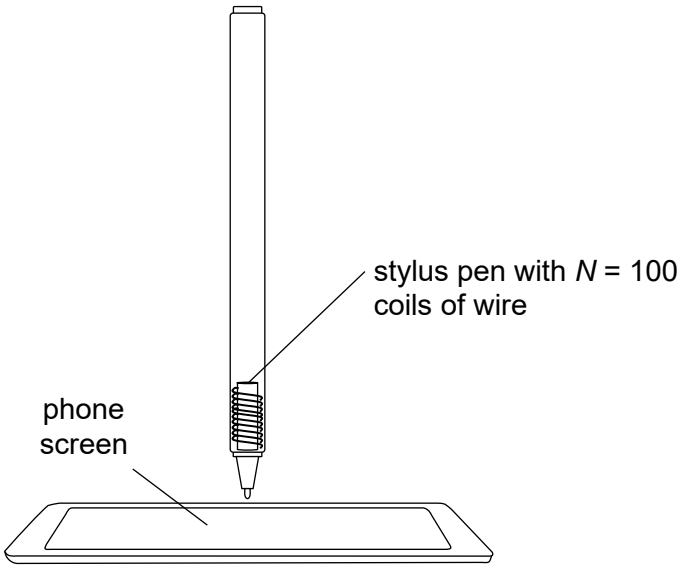

Fig. 6.1 (not to scale)

(a) State the two laws of electromagnetic induction.

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2. .....

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.... [2]

(b) The stylus pen does not have its own power source. It requires energy from the phone.

Explain how the stylus pen obtains its energy from the phone.

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.... [2]

(c) During operation, the magnetic flux density generated from under the phone screen alternates at a frequency of 750 kHz. As a result, the coil inside the stylus pen experiences a rate of change of magnetic flux density $\frac{dB}{dt}$ given by the equation

$$\frac{dB}{dt} = \left[\left(1.5\times10^{6}\right)(\pi)B_0\right]\cos\left(\left(1.5\times10^{6}\right)(\pi)t\right)$$

(i) The pen requires a peak voltage of 0.80 V to operate.

Calculate the value of B_0.

B_0 = ... T [2]

(ii) The Earth's magnetic field is constant at about $50\ \mu$T.

Suggest whether the Earth's magnetic field will disrupt the operation of the stylus pen.

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..... [1]

(iii) The effective resistance of the circuit housed within the stylus pen is $2.0\ \Omega$.

Find the average power generated when the pen is in operation.

average power = …….. W [2]

[Total: 9]