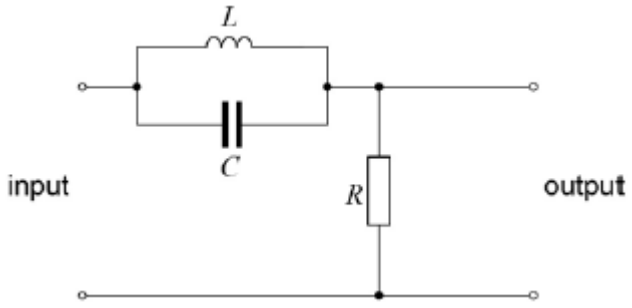
Q1. An engineer uses copper cable to connect an intercom system between her office and workshop. The signals have to travel a long distance and she finds that interference (hum) from the mains supply is a problem.
She reduces the interference using a filter tuned to the frequency of the mains supply. The mains frequency is 50 Hz.

Figure 1 shows her solution which is based on a parallel *L*–*C* resonant circuit.

Figure 1



(a) The engineer uses a 2.0 H inductor.

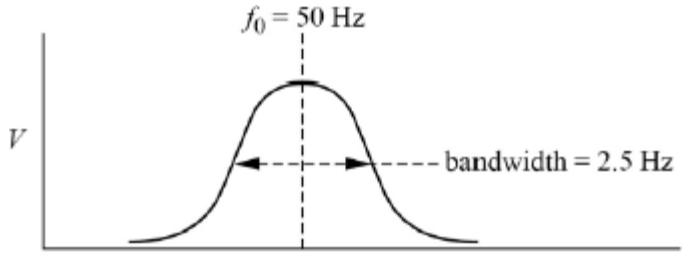
Calculate the required value for C for the filter to operate at 50 Hz.

capacitance = ... F

(2)

Figure 2 is the response curve for the inductor-capacitor circuit which shows how the pd *V* across the inductor-capacitor circuit varies with frequency.

Figure 2



frequency / Hz

(b) Calculate, from the graph, the Q factor of the inductor-capacitor circuit.

Q factor = ...

(1)

(c) The inductor is replaced to one that has an inductance of 8.0 H and a lower resistance than that of the original inductor. The capacitor is not changed. Describe how this change affects the response curve of the inductor-capacitor circuit.

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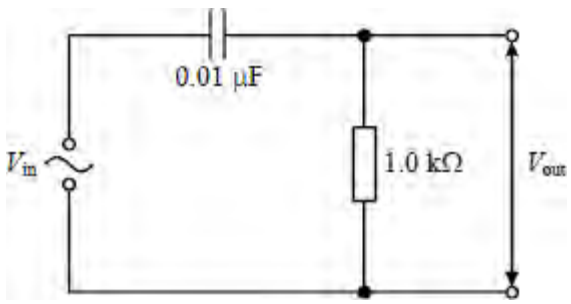
(2)
(Total 5 marks)

Q2. The figure shows the circuit of a high-pass filter. The ac source has a variable frequency.



(a) (i) Calculate the frequency at which the reactance of the capacitor is 1.0×10^3 Ω.

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(ii) Explain why $\frac{V_{out}}{V_{in}}$ will have a low value at low frequencies.

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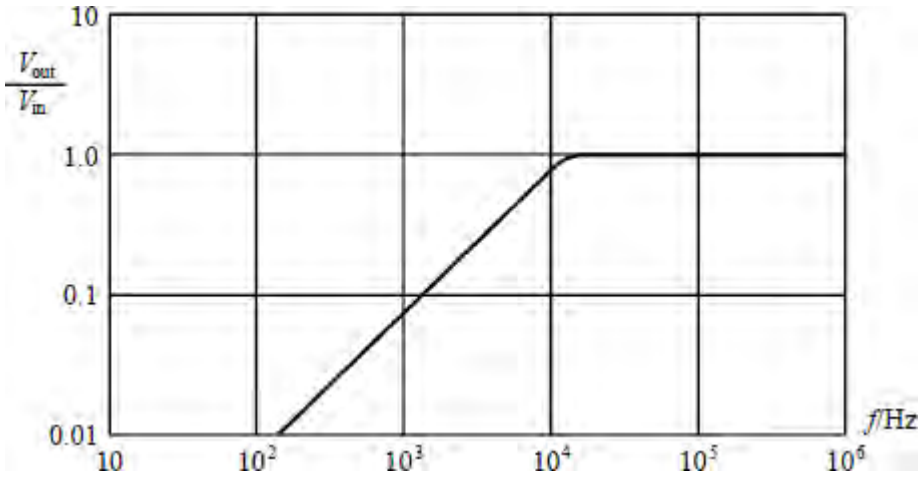
(4)

(b) The variation of $\frac{V_{out}}{V_{in}}$ with frequency for the high-pass filter is shown below.



Explain, without further calculation, the form of the characteristic.

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(2)
(Total 6 marks)

Q3. In order to reduce the bandwidth needed for transmission of an audio speech signal, the signal is filtered to remove high frequencies.

(a) Explain what is meant by the **bandwidth** of a signal.

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(2)

(b) Name the type of filter needed to remove high frequencies.

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(1)

(c) (i) Draw the circuit diagram of a passive filter to remove high frequencies, using a resistor and a capacitor.

Label the input and the output.

(2)

(ii) The resistor in the filter has a value of 1 kΩ.

Calculate the capacitor value required to give a breakpoint frequency of 4.0 kHz.

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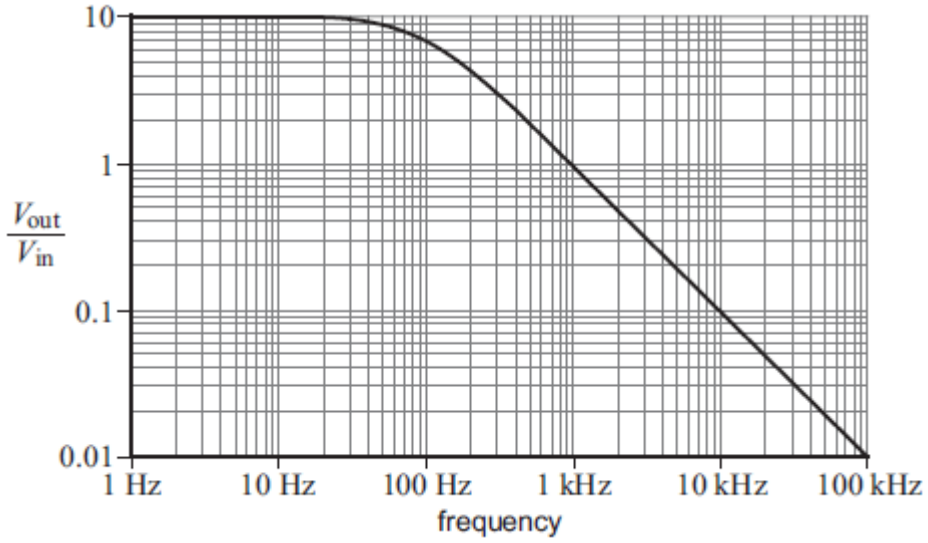
(3)

(d) The graph shows the response of a different filter to remove high frequencies.



(i) State how the graph shows that this must be an **active** filter.

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(1)

(ii) Circle the value closest to the breakpoint frequency of this filter.

30 Hz 100 Hz 200 Hz 1 kHz

(1)

(iii) A 2 V, 5 kHz signal is applied to the input of this filter.

Calculate the output signal voltage.

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(2)

(Total 12 marks)

Q4. A student finds that there is too much high frequency noise (hiss) on the audio frequency signal from a radio receiver he has constructed.

(a) What type of filter is required to pass the wanted signal and reduce the noise?

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(1)

(b) Draw the circuit diagram of a passive filter that would improve the quality of the signal. Label the input and the output.

(4)

(c) The components he chooses have values of 10 kΩ and 10 nF.
Calculate the breakpoint frequency of this filter.

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(3)

(d) State with a reason whether this would be suitable for a full range audio frequency signal.

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(2)
(Total 10 marks)