Question 1.

For the circuit shown in *Figure 1* use nodal analysis to calculate V_C :

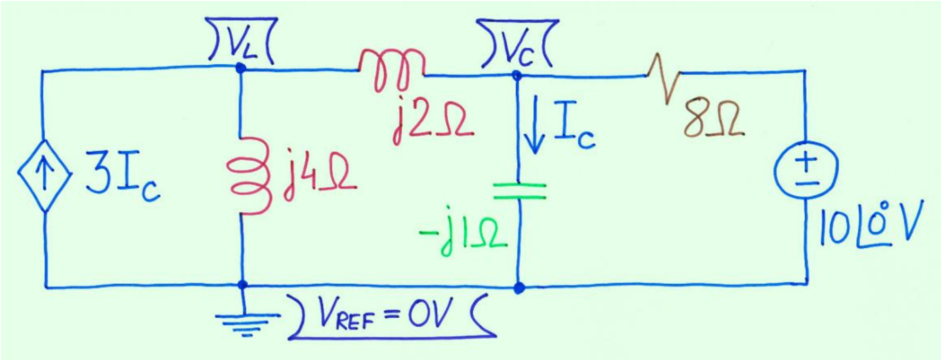

Figure 1

Question 2.

For the circuit shown in *Figure 2* use mesh analysis to calculate current I_C :

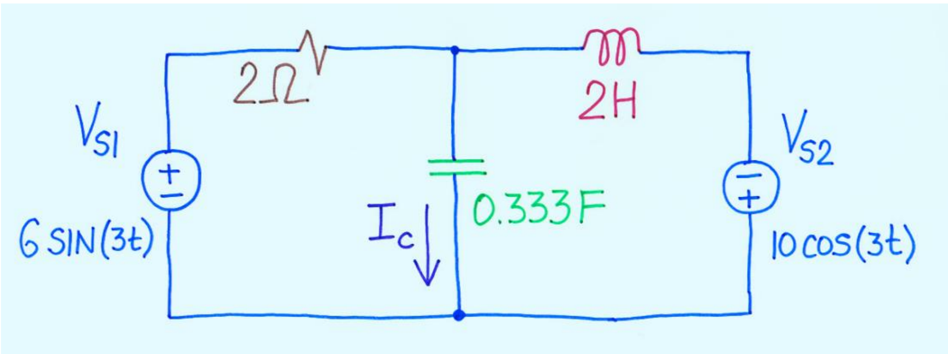

Figure 2

Question 3.

For the circuit shown in *Figure 3* determine the Thevenin's equivalent circuit.

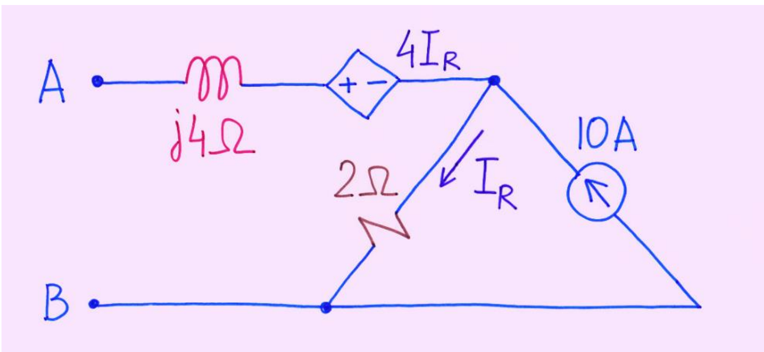

Figure 3

Question 4.

Calculate the RMS value for the voltage signal shown in *Figure 4*.

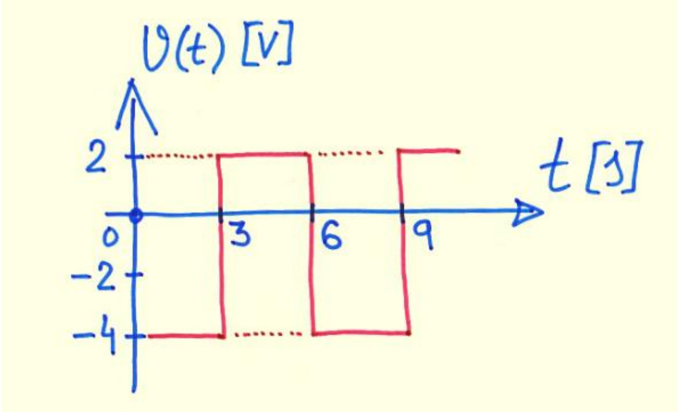

Figure 4

Question 5.

For the circuit in *Figure 5* calculate:

a) Resonant frequency in [Hz], Q factor and Bandwidth in [Hz]
b) Approximate half-power frequencies
c) Current magnitude at resonance
d) Capacitor and inductor voltage phasors at resonance
e) Value of the capacitance C_{NEW} for which the Q factor will decrease 10 times

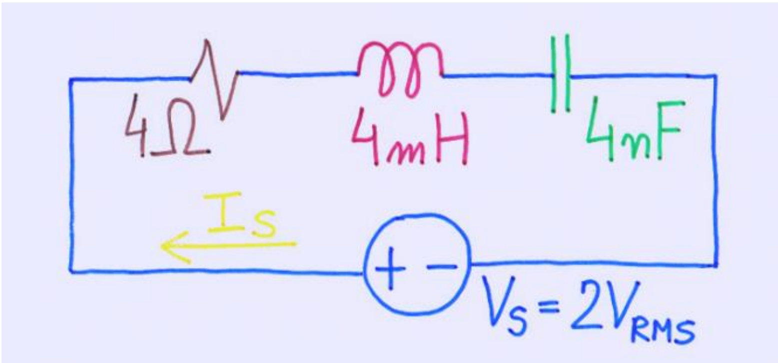

Figure 5

Question 6.

For the 2-port network with magnetically coupled coils shown in *Figure 6*, calculate z parameters.

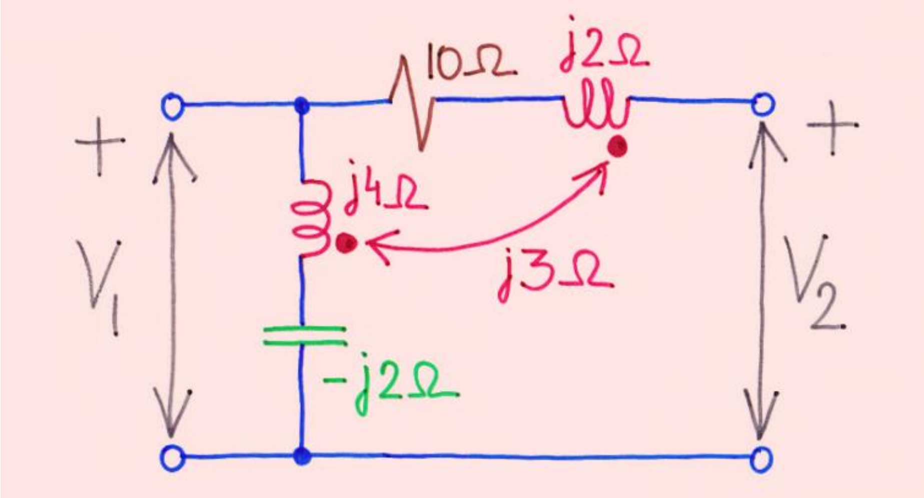

Figure 6

Bonus Question 7. (optional)

For the circuit shown in *Figure 7*:

a) Sketch magnitude and phase Bode plots.
b) What type of filter is this?

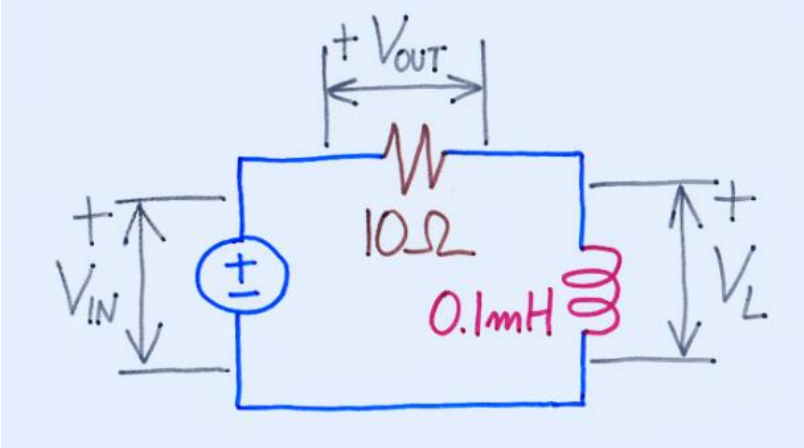

Figure 7

ECT Formula Sheet

Voltage divider rule:
$V_1 = \frac{Z_1}{Z_1+Z_2+\cdots+Z_n} V_s$

Current divider rule:
$I_1 = \frac{Y_1}{Y_1+Y_2+\cdots+Y_n} I_s$

Frequency: $f\ [Hz] = \frac{1}{T[s]}$

Angular frequency: $\omega = 2\pi f$

Inductor reactance: $X_L = \omega L$

Capacitor reactance: $X_C = -\frac{1}{\omega C}$

Impedance magnitude (R and X are in series):
$|Z| = \sqrt{R^2 + X^2}$

Impedance angle: $\theta_Z = \tan^{-1}\frac{X}{R}$

Inductor impedance: $Z_L = \omega L \angle 90^0 = j\omega L$

Capacitor impedance: $Z_C = \frac{1}{\omega C}\angle -90^0 = \frac{1}{j\omega C}$

Resistor impedance: $Z_R = R\angle 0^0$

Admittance: $Y = \frac{1}{Z}$

$\sin(\theta) = \cos(\theta - 90^0)$

Power factor: $pf = \frac{P}{|S|} = \cos(\theta)$,
Power factor angle: $\theta = \theta_v - \theta_i = \tan^{-1}\frac{Q}{P}$

Active power (single phase): $P = V_{rms} I_{rms} * pf$

Reactive power (single phase): $Q = V_{rms} I_{rms} \sin(\theta)$

Complex power (single phase): $S = P + jQ$

Apparent power(single phase):
$|S| = V_{rms} I_{rms} = \sqrt{P^2 + Q^2}$

3-phase active power (balanced source and load):
$P_{3\emptyset} = \sqrt{3}\, V_{L\,rms} I_{L\,rms} * pf = 3P_{1\emptyset}$

Transformer reflected impedance: $Z_1 = \left(\frac{N_1}{N_2}\right)^2 Z_2$

Ideal transformer ratio: $\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$

Loosely coupled coils:
$V_1 = j\omega L_1 I_1 + j\omega M I_2$
$V_2 = j\omega M I_1 + j\omega L_2 I_2$
$M = k\sqrt{L_1 L_2}$

Resonant frequency: $f_r = \frac{1}{2\pi\sqrt{LC}}$

Q-factor: $Q = \frac{f_r}{BW} = \frac{f_r}{f_2 - f_1}$ (f_1 and f_2 are the half power frequencies).

At resonance:
$V_C = V_L = Q_s V_R$ (series resonance)
$I_C = I_L = Q_p I_R$ (parallel resonance)

z - parameters:
$V_1 = z_{11} I_1 + z_{12} I_2$
$V_2 = z_{21} I_1 + z_{22} I_2$

y - parameters:
$I_1 = y_{11} V_1 + y_{12} V_2$
$I_2 = y_{21} V_1 + y_{22} V_2$

Nodal Equations:
$Y_{11}V_1 - Y_{12}V_2 = \sum_{to\,n1} Ieq_i$
$-Y_{21}V_1 + Y_{22}V_2 = \sum_{to\,n2} Ieq_i$

Mesh Equations:
$Z_{11}I_1 - Z_{12}I_2 = \sum_{loop1} Eeq_i$
$-Z_{21}I_1 + Z_{22}I_2 = \sum_{loop2} Eeq_i$

Thevenin's Equivalent Circuit:
$V_{TH} = V_{o/c}$
$Z_{TH} = \frac{V_{o/c}}{I_{s/c}}$

Maximum Power Transfer Theorem:
$Z_{load} = Z_{TH}^*$

$P_{max} = \frac{|V_{TH}|^2}{4R_{TH}}$

Magnitude in dB: $|T|_{dB} = 20\log_{10}|T|$