Name _____

*By writing or printing my name in the space above, I hereby affirm that I have neither given nor received assistance in preparing solutions for this exam.*

EE 3340

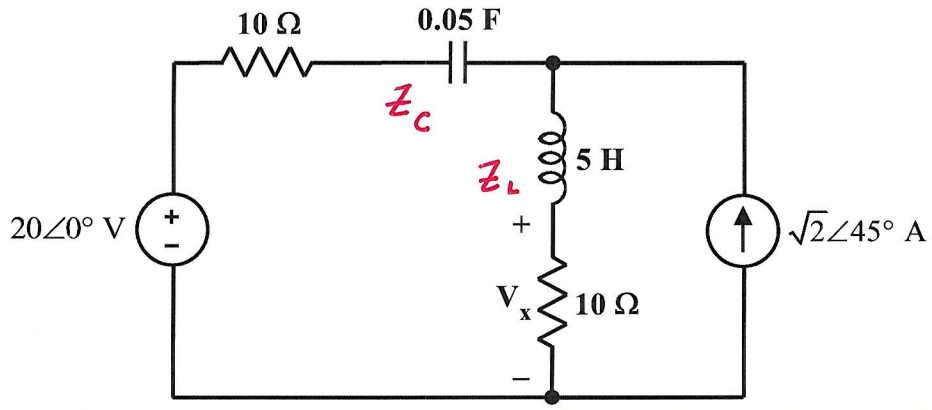
# Final Exam

Spring Semester 2022

**Show all work *neatly and completely.***
**Credit will not be given for work not shown.**

There are 7 problems provided here. Choose any 6 to submit for grading. Each of the 6 problems you submit will be worth a maximum of 25 points, making 150 points the maximum total possible score on the exam. There will be very little partial credit; take your time and ***check your work***.

1. Determine $\mathbf{V}_x$ in polar form if $\omega = 2$ rad/s.




$$Z_C = \frac{1}{j(2)(0.05)} = -j10\,\Omega, \quad Z_L = j(2)(5) = j10\,\Omega$$

Use the superposition method.

Contribution from the voltage source:

$$V_{x1} = \frac{10}{10 + Z_C + Z_L + 10} \cdot 20\angle 0^\circ = 10\angle 0^\circ \text{ V}$$

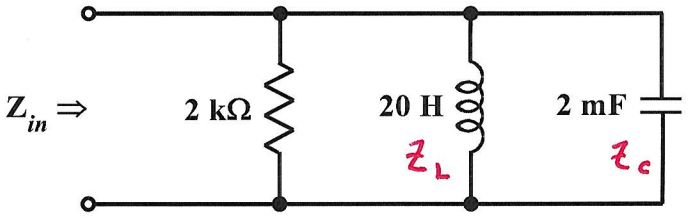
Contribution from the current source:

$$V_{x2} = 10 \cdot \frac{10 + Z_C}{10 + Z_C + Z_L + 10} \cdot \sqrt{2}\angle 45^\circ$$

$$= \frac{1}{2} \cdot 10\sqrt{2}\angle -45^\circ \cdot \sqrt{2}\angle 45^\circ = 10\angle 0^\circ \text{ V}$$

$$\therefore V_x = V_{x1} + V_{x2} = 20\angle 0^\circ \text{ V}$$

2. Determine the input impedance, $\mathbf{Z}_{in}$, in rectangular (Cartesian) form if $\omega = 5$ rad/s.




$$z_L = j(5)(20) = j100\ \Omega$$

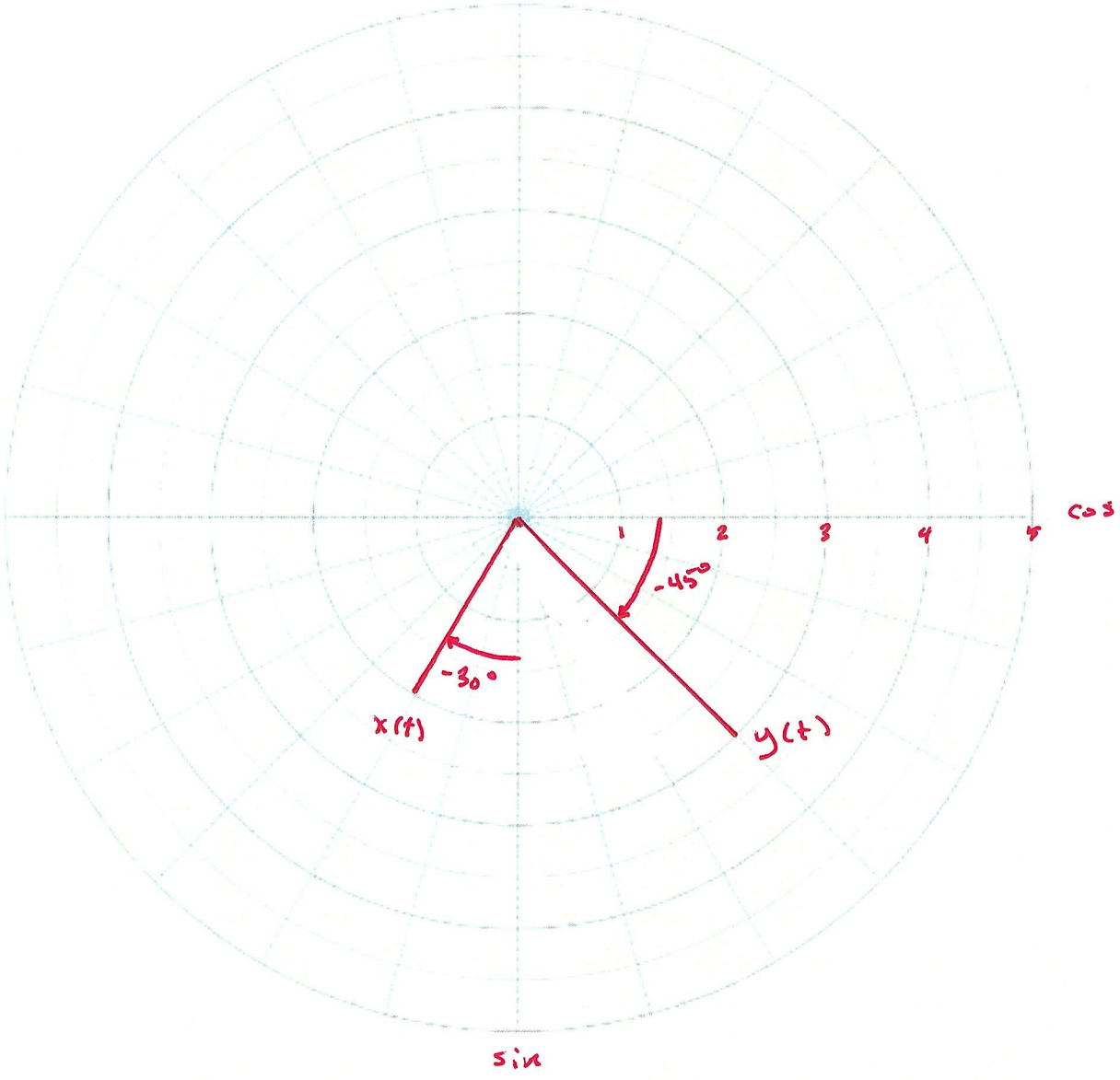
$$z_C = \frac{1}{j(5)(2\times10^{-3})} = -j100\ \Omega$$

$$z_{in} = \frac{1}{\frac{1}{2000} + \frac{1}{j100} + \frac{1}{-j100}}$$

$$= 2000\ \angle 0^\circ\ \Omega$$

3. Given two signals, $x(t) = 2\sin(\omega t - 30°)$ and $y(t) = 3\cos(\omega t - 45°)$:

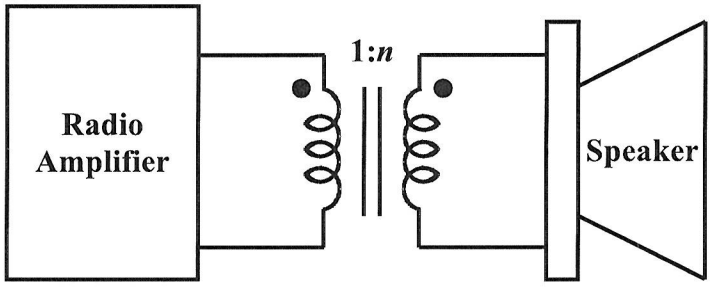
   a. Accurately sketch a phasor diagram showing the proper length and orientation of each of these two signals.




   b. What is the phase angle of $x(t)$ ***with respect to*** $y(t)$?

$-30° - 90° + 45° = -75°$

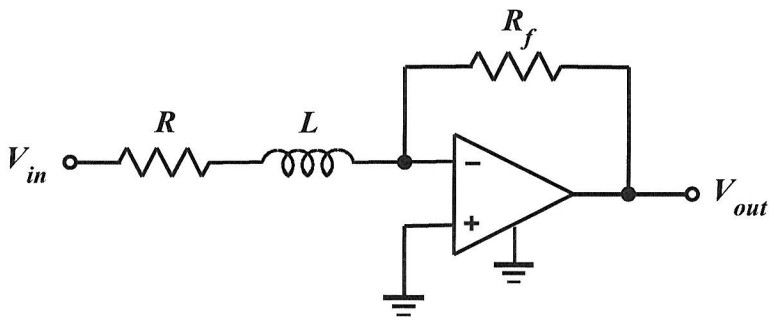
4. As a final step in the design process, the output stage of a radio amplifier must be matched to the impedance of its speaker by using an impedance-matching transformer as shown below. The selected speaker has input impedance equal to $4\Omega$, and the amplifier requires a load impedance of 2500 $\Omega$ for optimum performance. Assume the transformer is ideal, and determine the necessary turns ratio to accomplish the desired match




$$\left(\frac{1}{n}\right)^2 (4\Omega) = 2500\ \Omega$$

$$\Rightarrow \quad \frac{1}{n} = \sqrt{\frac{2500}{4}} = 25$$

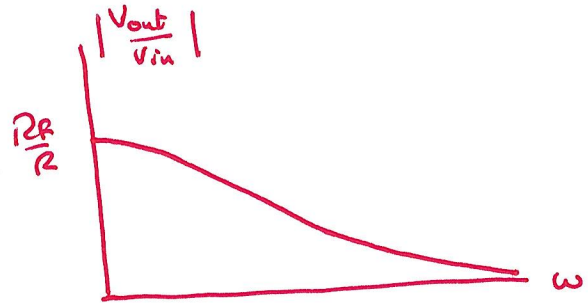
5. Determine the voltage transfer function of the filter circuit shown below and classify the filter as LP, HP, BP or BS. ***Clearly*** explain your reasoning.




$$\frac{V_{out}}{V_{in}} = -\frac{R_f}{R + j\omega L}$$

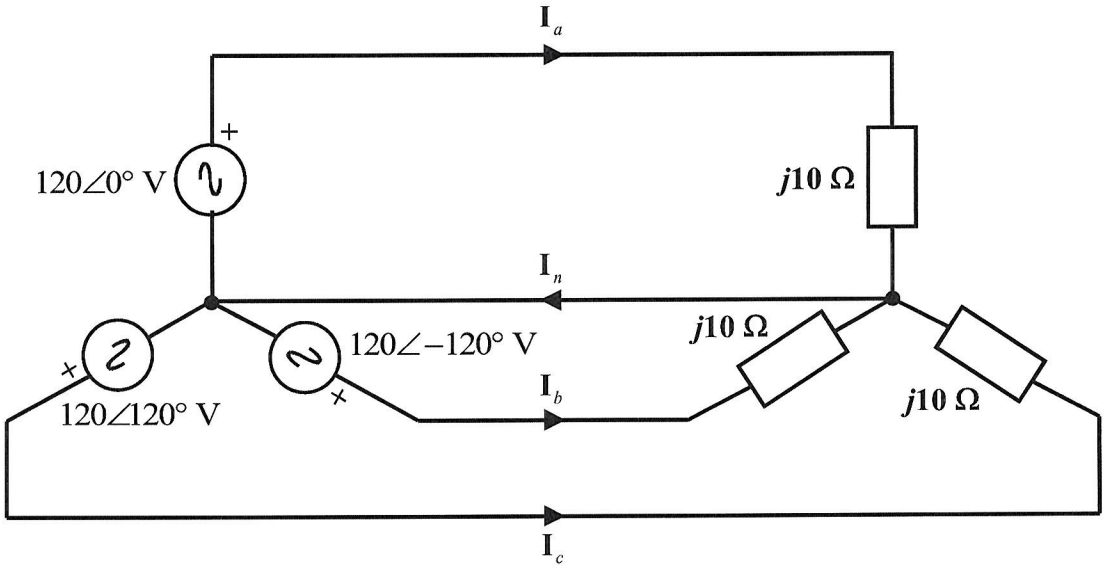
$$\omega \to 0 \Rightarrow \left|\frac{V_{out}}{V_{in}}\right| \to \frac{R_f}{R}$$

$$\omega \to \infty \Rightarrow \left|\frac{V_{out}}{V_{in}}\right| \to 0$$




This is a LP filter.

6. A balanced three-phase distribution system is shown below. Determine the value of the neutral current, $\mathbf{I}_n$, in rectangular (Cartesian) form.




Balanced $\Rightarrow$ $I_n = 0$

Proof:

$$I_a = \frac{120\angle 0^\circ}{j10} = 12\angle -90^\circ \text{ A} = -j12 \text{ A}$$

$$I_b = \frac{120\angle -120^\circ}{j10} = 12\angle -210^\circ \text{ A} = 12\angle 150^\circ \text{ A}$$

$$= 12\cos 150^\circ + j12\sin 150^\circ$$

$$= -12\cos 30^\circ + j12\sin 30^\circ$$

$$I_c = \frac{120\angle 120^\circ}{j10} = 12\angle 30^\circ = 12\cos 30^\circ + j12\sin 30^\circ$$

$$I_n = I_a + I_b + I_c$$

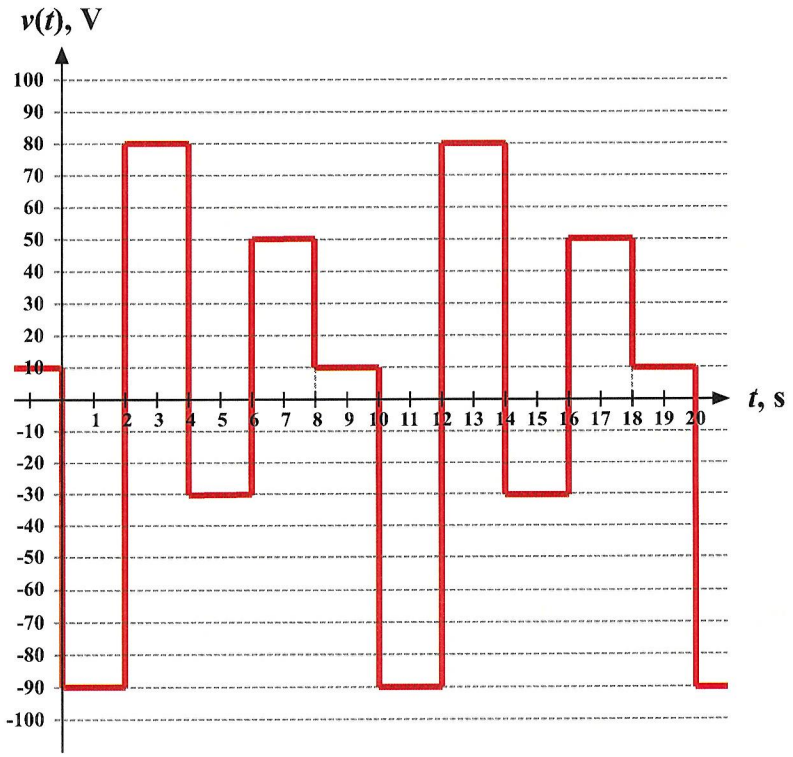
$$= -j12 - 12\cos 30^\circ + j12\sin 30^\circ + 12\cos 30^\circ + j12\sin 30^\circ$$

$$= -j12 + j24\sin 30^\circ$$

$$= -j12 + j12$$

$$= 0 \text{ A}$$

7. The waveform shown below is periodic with $T = 10$ s. Determine the ***average and effective*** values of $v(t)$.




$$V_{ave} = \frac{-90 + 80 - 30 + 50 + 10}{5} = 4\ V$$

$$V_{rms} = \sqrt{\frac{(-90)^2 + (80)^2 + (-30)^2 + (50)^2 + (10)^2}{5}}$$

$$= 60\ V$$