ECE 3600 Exam 1 given: Spring 23

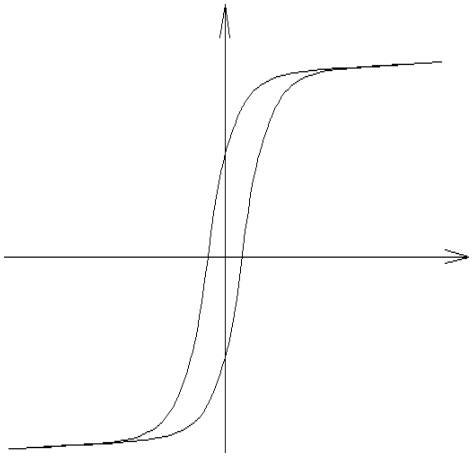
DO NOT use erasable ink

First part, Closed book, Closed notes, No reference sheet (pink sheet), No Calculator.

(12 pts) Write Legibly! If I can't read what you've written or your answer is ambiguous, I'll assume you don't know.

1. Decribe how a combined-cycle, natural gas, power plant works and achieves its high efficiency?

2. a) Name the common curve shown at right.



b) Label the vertical and horizontal axes with the correct letters. Alternatively, you may indicate which axis is related to voltage and which is related to current by labeling with:

$$N \cdot I \qquad \text{and} \qquad V = N \cdot \frac{d}{dt}\phi$$

c) Many electrical devices we study contain a something which is characterized by this curve. What is that?

3. Why do transformers have a maximum voltage rating?
That is, what bad thing are you trying to limit by limiting the voltage?

4. Why do transformers have a maximum current rating?

When you are done with this part, turn it in to get the second part.

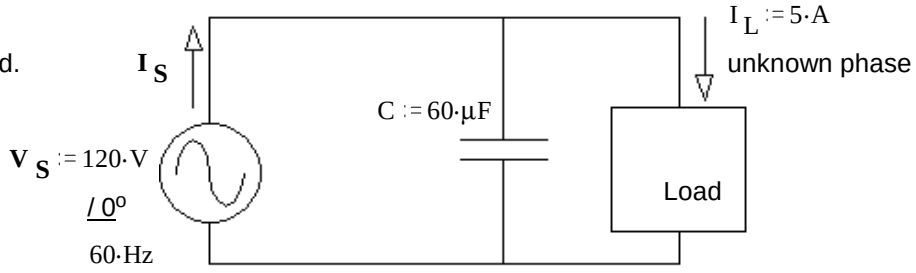
Questions _____/ 12

This part of the exam is open book, open notes. You MUST show work to get credit. Show the correct units for each value. Assume voltage and current values are RMS and $f := 60 \cdot Hz$. Assume normal abc sequence and balanced conditions for all 3ϕ.

1. (23 pts) An capacitor is used to completely correct the power factor of a load.

Find the following:

a) The power consumed by the load.
P_L = ?



If you can't find this power, mark an x here _____ and assume $P_L = 500\text{W}$ for the rest of the problem.

b) The power supplied by the source. P_S = ?

c) The source current (magnitude and phase). $\mathbf{I}_S$ = ?

d) The load can be modeled as 2 parts in series. Draw the model and find the values of the parts.

e) The capacitor, C, is replaced with a $80\ \mu\text{F}$ capacitor.

circle one

i) The **new** source current $|\mathbf{I}_S|$ is **greater** than that calculated in part c).

ii) The **new** source current $|\mathbf{I}_S|$ is **the same** as that calculated in part c).

iii) The **new** source current $|\mathbf{I}_S|$ is **less** than that calculated in part c).

_____ / 23

2. (32 pts) a) A 3-phase system consists of a generator, 3 lines and a load. At the generator the line voltage is 300-V, the total power is 12 kW, and the power factor is 0.82, lagging. The overall efficiency of the system is 90%. Each line has the same resistance (R_{line}) and reactance: $X_{line} := 1.2 \cdot \Omega$

   a) Find the line resistance. R_{line} = ?

   b) What is the line voltage at the load? **Do not** ignore the phase difference between the voltage and the current.

   c) Assume that the load is Y-connected and each branch is a resistor (R_{load}) in parallel with a reactance (X_{load}). Find the value of load resistance. R_{load} = ?

d) The power factor is corrected to 1 at the load. The generator line voltage remains 300V. What is the new efficiency?
Hint: You may interpret the power factor correction as though X_{load} has been eliminated.
Beware! The power given above is no longer valid.

_____ / 32

3. (33 pts) The parameters of a step-down transformer are shown below. The primary voltage is $V_S := 220\cdot V$

The transformer is loaded with $\mathbf{Z_L} = R_L + jX_L$ and the secondary current is $I_2 := 4\cdot A$

$R_m := 1.2\cdot k\Omega$ $R_s := 10\cdot\Omega$ $X_m := 1\cdot k\Omega$ $X_s := 12\cdot\Omega$ $N := 5$

a) The primary, source voltage provides 180 Watts $P_S := 180\cdot W$ Find R_L
Hint: draw the model with the load.

If you can't find R_L, mark here ___ , use $R_L = 9\Omega$ and move on.

b) Find the efficiency of the transformer.

c) Find X_L

d) Replace R_L and X_L with a single $R_L := 9.0 \cdot \Omega$

Assuming the transformer is now fully loaded, find the % voltage regulation $\%VR$ =?

e) Assuming the transformer is now fully loaded, find the transformer VA rating.

Prob 3 _____/ 33

Answers Questions _____/ 12 Total _____/ 100

Questions 1. The "waste" heat of a gas turbine is then used to run a steam cycle generator.

2. a) B-H curve or Hysteresis curve b) X-axis: H or $N \cdot I$ Y-axis: B or $V = N \cdot \frac{d}{dt}\phi$ c) The core
3. Core saturation
Insulation breakdown would happen at quite a bit higher voltage 4. Winding resistance & I^2R heating

Problems 1. a) $504 \cdot W$ b) $504 \cdot W$ c) $4.20 \cdot A \angle 0^o$ d) $R_L = 21.16 \cdot \Omega$ and $L_L = 34.6 \cdot mH$ e) i)

2. a) $0.504 \cdot \Omega$ b) $248.65 \cdot V$ c) $5.725 \cdot \Omega$ d) $91.9 \cdot \%$ 3. a) $8.33 \cdot \Omega$ b) $74.04 \cdot \%$ c) $6.213 \cdot \Omega$

d) $4.58 \cdot \%$ e) $196.7 \cdot VA$ Prrobably $200VA$)