# EE 30372, Spring 2021 <br> Exam 1 <br> 24 March, 2021 

Show all your work and your answers clearly on the test pages. In any plots and sketches, label and include units (if possible) on anything that might be of interest. For full credit, simplify your answers as much as possible. You may use calculators for numerical evaluations but no programming capabilities. This exam is closed-book, but you are free to use the onesided crib sheet you've assembled.

Remember that when three-phase voltages are given, they will be line-to-line by default. Voltage and current values are, unless otherwise noted, in rms.

Problem 1 (25) $\qquad$

Problem 2 (30) $\qquad$

Problem 3 (25) $\qquad$

Problem 4 (20) $\qquad$

Total (100)
$\qquad$

1. Short Answers (still make sure results are supported) (5 pts each)
(a) What is the line current magnitude for a $\Delta$-connected, $60-\mathrm{Hz}$, three-phase load at 480 V consuming 15 Hp ( $100 \%$ efficiency) at power factor 0.8 lagging?
(b) What size capacitor would you place in parallel with each of the phases in (a) to bring the power factor to 1.0 ?
(c) We have a 3-phase transformer in which each set of windings has a turns ratio of 1:3 between primary and secondary. We wire the primary side in $\Delta$ configuration and the secondary in $Y$. What will be the ratio between primary and secondary line voltages and the phase relationship?
(d) A balanced, three-phase, $\Delta$-connected generator is delivering 100 A of current at $-10^{\circ}$ degrees onto the A phase output line. What is the complex current in the CA phase inside the generator?
(e) The figure below presents windings in a rotor with DC field current having directions marked with the usual dot and x , and the shell of a two-pole stator whose windings create $\mathbf{B}_{\mathbf{s}}$. In the state shown, will the induced torque on the rotor be clockwise or counter-clockwise? Explain your reasoning. Preferred justification is force applied to rotor wires.

2. One of the back-up 3-phase, $4-$ pole, 60 Hz diesel generators north of campus is driven by a 1400 HP diesel engine and is rated for 1.2 MVA at power factor 0.8 lagging. It is set to maintain 4160 V at its terminals, and has its stator coils wired in Y-configuration. We model its output impedance as $j 5 \Omega$ in each phase, neglecting output resistance.
(a) (10 pts.) The generator is supplying, at its terminals, the rated power at PF 0.8 lagging. Find the internally generated voltage $\mathbf{E}_{\mathbf{A}}$ and sketch an accurate phasor diagram of its operation in this state.
(b) (10 pts.) How much reserve power and torque does the engine have while it is running under its rated full load? Assume $100 \%$ efficiency for the generator here.
(c) (10 pts.) Suppose now the work load is suddenly lost and the real power delivered drops to zero (not a cheery prospect in reality), and field current is unchanged. What is the reactive power output?

3. Above is the model of a single-phase transformer, rated for 50 kVA and $480 / 208 \mathrm{~V}$ for primary/secondary voltage. The impedance parameters are $X_{p}=1 \Omega, R_{p}=0.3 \Omega$, $X_{s}=0.3 \Omega, R_{s}=0.1 \Omega$. We neglect shunt impedances in the circuit, but model core loss at 1 kW .
(a) (8 pts.) Find the equivalent circuit, with all entities referenced to the primary, but all four components shown separately in the circuit diagram. You do not need to do any conversions on the load.
(b) (7 pts.) Convert your circuit in (a) into per-unit and sketch it below.
(c) (10 pts.) The capacitors for power factor correction have been engaged in parallel with the load, and turn out to be too large, so our transformer is operating at rated capacity with PF 0.8 leading. Find the voltage regulation and efficiency in this state.

4. (a) (10 pts.) We have our transformer from class, with turns ratio of $2: 1$ from H to X , wired as shown. If $V_{p}=120 \angle 0^{\circ} V$, what is $V_{s}$ ? Explain/analyze.
(b) (10 pts.) We now remove the new wiring we attached in (a). Sketch a wiring diagram of this transformer connected to function as an autotransformer reducing voltage from 120 V to 100 V . Label all the H and X terminals in your diagram. (You may "unfold" the coils for a more convenient stacking.) Given that this transformer is rated at 1 kVA for conventional $480 / 240$ or $240 / 120$ operation, how much power can it transfer in our autotransformer arrangement, with 120 V on the primary?
