ECE3600 Final given: Fall 10

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

(78 pts) Questions This part of the exam is **Closed book, Closed notes, No Calculator**.

1. What does it mean when a 3-phase system is "balanced"?

2. a) The Gadsby power plant is used to supply: base load or peak load (circle one)

   b) The Intermountain Power Plant (A large coal-fired power plant near Delta, Utah) is used to supply:

   base load or peak load

3. What four things happen to the water in a Rankin-cycle power plant. In the center column of the table below, list them in the order that they occur, starting where the energy is added to the water. Note: if you find the table confusing, read the note below it.

   For each process, show the state of input and the output, select from A, B, C, and D, at right and fill in the left and right columns.

   A. Low pressure liquid
   B. High pressure liquid
   C. Low pressure steam
   D. High pressure steam

If you do both, indicate which should be graded

Input	Process	Output
	1.	
	2.	
	3.	
	4.	

Note: This question may also be answered by drawing a diagram of the cycle. It should show all the same information.

4. Explain the basics of a natural gas combined-cycle power plant, especially give the reason for its high efficiency.

5. The B-H curve causes a number of problems. Name at least 3.

6. a) List the bases of a per-unit system.

   b) When analyzing a power system, which, if any, of these bases should be constant throughout the system?

   c) For those bases that change from place to place throughout the system, which is the primary one that changes and what type of part causes the changes?

   d) Show how to find the remaining bases from those listed in parts b) and c).

7. The power angle of a synchronous generator is limited to what range of values?

8. a) List at least 3 different synchronous motor speeds in the US, in rpm.

   b) How are typical induction motor rated speeds related to the synchronous motor speeds?

   a) When the power is first turned on to an induction motor, what is the slip? s = ?

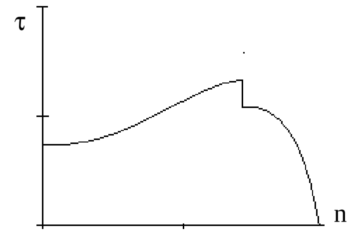
   b) When an induction motor is operated at its rated output, what is a typical slip? s = ?

9. An induction motor is operated with a variable-frequency drive.

   a.1) How is the motor operated at slower-than-normal speeds?

   a.2) Is there something else which must also be reduced? If yes, what and why?

   b) How is the motor operated at higher-than-normal speeds?



10. a) The torque-speed curve shown at right is typical of what type of motor? (More than one answer is possible).

    b) These motors have a special component not found in the other motors we studied. What is it?

11. a) DC motors are usually classified by the way the field is created. What are the 4 types of DC motors.

    1.   2.

    3.   4.

    b.1) One of these types is also commonly used with AC power, which one?

    b.2) What is it called when it is used with AC power?

    b.3) Name at least 3 important characteristics of this type of motor.

12. List at least 4 common long-distance high-voltage transmission line voltages discussed in this class.

13. What insulates the wires from one another in an overhead transmission line?

14. Fill in the table below to show how the electrical characteristics of a transmission line (left column) are affected by the physical characteristics (top row). You may use the abbreviations at right.

    inc = increase
    dec = decrease
    n/c = little or no effect

	Distance from line to line if you increase D	radius of a line if you increase r	bundling
resistance, r			
inductance, l			
capacitance, c			
corona discharge			

15. Can the voltage at the receiving-end of a transmission line ever be greater than the voltage at the sending-end? (Assume no power generation at the receiving-end.) If yes, how?

F10 Open book

1. (15 pts) A single-phase, 240-V source is connected to two loads. The source provides 2500W and 11A. Load 1 consumes 1500W at a power factor of 0.8.

   In order to find the following, you may have to make some assumptions. If you do, be sure to clearly state your assumption in such a way that I can tell that you know what the other assumption might be.

   a) Find the complex power consumed by load 2.

   b) Load 2 can be modeled as 2 parts. Draw a model and find the values of the parts.

2. (20 pts) A 3-phase system delivers 480-V (line voltage) , 60-Hz 3-phase power of 15 kW to a load with a 75% lagging power factor. Each line has a resistance of 0.47 Ω. ("delivers" means those are the values at the load.)

   a) Three Y-connected sources supply the power. What voltage do they each supply (magnitude)?

   b) Find the total power lost in the lines and the overall efficiency of the system.

   c) Three capacitors are Y-connected at the load to correct the power factor. Find the capacitor value(s).

   d) The source voltage is adjusted so that the load power remains 15 kW.
   What is the new efficiency of the system with the capacitors of part c).

3. (30 pts) A 3-hp dc motor has the following nameplate information: 160 V, 1200 rpm, 16 A, $R_A = 0.5\ \Omega$, and $R_F = 300\ \Omega$. The field is shunt connected and the 16 A <u>includes</u> the field current. Assume rotational losses are constant.
   a) Find the efficiency of the motor at nameplate operation. (Include the field in your calculations) $1 \cdot hp = 745.7 \cdot W$
   b) Find the rotational losses at nameplate operation.
   c) Find the required current for a developed power of 1.5 hp with $V_T = 160$ V.
   d) Find the output power if the developed power is 1.5 hp with $V_T = 160$ V.
   e) Find the shaft speed if the developed power is 1.5 hp with $V_T = 160$ V.
   f) A deranged Mickey Mouse chews through part of the field winding so that the field current drops and the field flux drops to 60% of its former value. Find the shaft speed if the developed power is still 1.5 hp with $V_T = 160$ V. Note: before you make this problem much harder than it really is, It is OK to use the same E_A and I_A as you found above in parts c) & d).

4. (32 pts) A 230 kV transmission line has the following length and line parameters. $S := siemens$

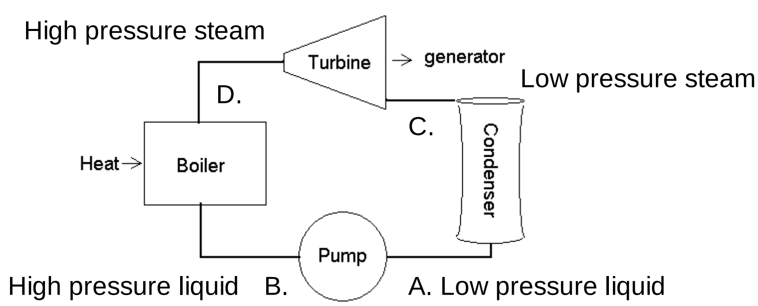
$$len := 180 \cdot km \qquad r := 0.12 \cdot \frac{\Omega}{km} \qquad x := 0.5 \cdot \frac{\Omega}{km} \qquad g := 0 \cdot \frac{S}{km} \qquad y := 3.6 \cdot 10^{-6} \cdot \frac{S}{km}$$

   a) Choose the most appropriate model for this transmission line and draw it, including the impedance and/or admittance value(s).
   b) Add a load impedance (at the receiving, or $\mathbf{V_R}$ end) on the drawing above. The load is 250Ω with a power factor of 0.88, **leading**. The line-to-line voltage at the source is 230 kV. Assume the source voltage, $\mathbf{V_S}$, phase is $\angle 0°$. Find the line current, $\mathbf{I_{Line}}$ (not $\mathbf{I_S}$) in any complex-number form.
   Note: Don't try any shortcuts here. You need to do your math with full complex numbers, not magnitudes. There is a messy calculation of impedance, so work carefully. $\mathbf{I_{Line}}$ = ?
   c) Same load and conditions as part b). Find the load phase voltage, $\mathbf{V_R}$, magnitude and phase. $\mathbf{V_R}$ = ?
   d) Do you see something weird about $|\mathbf{V_R}|$ and $|\mathbf{V_S}|$? If yes, what is it and what is the cause?
   e) What is the line voltage at the load (magnitude)?
   f) How much total power is delivered to the load?
   g) What is the "power angle" (δ)?

P.S. Services for Mickey will be held Friday after finals at the closest Bar and Grill.

Answers

1. The 3 voltages are equal, the 3 currents are equal and the 3 loads are equal.
2. a) peak load b) base load
3.



4. Natural gas is burned in a gas turbine which spins a generator for electricity. The exhaust or "waste" heat from this gas turbine is used to boil water for a Rankin-cycle. the steam turbine generates more electricity. Each of these cycles has an efficiency of about 40%, together the efficiency is about: "waste" $40 \cdot \% + 40 \cdot \% \cdot 60 \cdot \% = 64 \cdot \%$

5. 3 of these: Core losses   Nonlinearities, esp. in the currents   Requires larger, heavier cores
   Sets voltage limits   3rd harmonic currents   Requires more windings so that the core flux can be less

6. a) S_{base} V_{base} I_{base} Z_{base}

   b) S_{base} c) V_{base} Transformers   d) $I_{base} = \dfrac{S_{base}}{\sqrt{3}\cdot V_{base}}$ $Z_{base} = \dfrac{V_{base}^{2}}{S_{base}}$

7. $0^o < \delta < 90^o$

8. a) $3600\cdot rpm$ $1800\cdot rpm$ $1200\cdot rpm$ $900\cdot rpm$ $720\cdot rpm$ etc..   b) They are a little less (about 5% less)

   c) 1 d) $0.05 = 5\cdot\%$ 9. a.1) The frequency is less than 60Hz.

9. a.2) The voltage must be reduced to prevent saturation of the core.   b) The frequency is greater than 60Hz.

10. a) Split-phase or single-phase induction motor   b) A centrifugal switch

11. a) 1. Separately excited   2. Series excited   3. Shunt excited   4. Permanent magnet

    b.1) Series excited   b.2) Universal motor

    b.3) 3 of these   Torque increases significantly as load is increased   Noisy
    High torque   High power-to-weight ratio   High power-to-size ratio

12. 4 of these: $115\cdot kV$ $138\cdot kV$ $230\cdot kV$ $345\cdot kV$ $500\cdot kV$ $765\cdot kV$ 13. Air (and distance)

14.

	Distance from line to line. If you increase D	Radius of a line. If you increase r	bundling
resistance, r	n/c	dec	dec
inductance, l	inc	dec	dec
capacitance, c	dec	inc	inc
corona discharge	dec	dec	dec

15. Yes   The load hooked to a transmission line has a leading power factor.

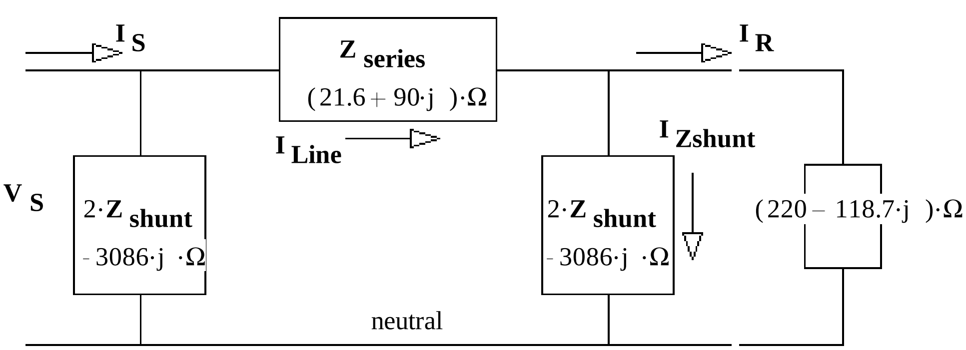
Open Book

1. The following answers are not the only possible   a) $(1 - 0.277j)\cdot kVA$ b) parallel 57.6-Ω resistor and 12.7-μF cap.

2. a) $285.7\cdot V$ b) $94.8\cdot\%$ c) $152\cdot\mu F$ d) $97\cdot\%$

3. a) $87.4\cdot\%$ b) $118\cdot W$ c) $7.15\cdot A$ inc. field: $7.68\cdot A$ d) $1.34\cdot hp$ e) $1233\cdot rpm$ f) $2055\cdot rpm$

4. a) Medium-length line model:



b) $(574 + 97.9\cdot j)\cdot A$

c) $140\cdot kV \angle -22.6\cdot deg$

d) $|\mathbf{V_R}|$ is bigger than $|\mathbf{V_S}|$
This can happen when the load power factor is leading.

e) $242.4\cdot kV$ f) $207\cdot MW$

g) $22.6\cdot deg$