PHYS345 Final Exam, Spring 2003

This is a closed book exam. One 3"x5" note card is permitted; this card should be turned in with your exam papers.

Programmable calculators and graphing calculators may be used during this exam.

Since this exam booklet may be separated for grading; it is important to:

*Show ALL work on problem sheet and only on that sheet.*

Please read questions carefully.

Credit may be lost inadvertently if solutions are not neat and orderly.

Be careful with units, signs, and significant figures.

1. (15 points) Short Questions

   a) Power consumed by a motor has a form of \( P_v + jQ \). How do you correct the power factor back to unity?

   b) List three conditions for series RLC circuit at resonance.

   c) What is advantage of using a three phase power besides it provides higher voltage than a single phase power.
d) A counter clockwise current is placed in a uniform magnetic field as shown in the figure. Indicate the force direction in left and right arms.

e) Describe how electricity is generated.

2. (15 points)
   a) Find the current $i_1$ and $i_2$. $R_1=3 \, \Omega$, $R_2=1 \, \Omega$; $R_3=6 \, \Omega$.
   b) Replace the two dc current sources with ac sources of $1\cos(100t)$ A (left) and $2\cos(100t)$ A (right), write down the expression $i_1$ and $i_2$ again.
3 (10 pts): Replace the 5H inductor with a 5 Ω resistor and calculate the time constant of the circuit and the voltage on the capacitor after the switch is closed for long time. 

\( V_S = 5V \)
4. (20pts)
(a) (2.5pts) Write the transfer function for this filter.
(b) (5pts) Design a high-pass RC filter with a characteristic frequency of 80 Hz using a capacitor of 2.0 \( \mu \text{F} \).
(c) (2.5pts) What is the new characteristic frequency when the filter is loaded with 50 ohm?
(d) (10pts) redesign a circuit which will not suffer from loading effects such as encountered in part c, but still with 80 Hz characteristic frequency. In addition, an amplification of 10 is also needed in this new circuit. You are given an op-amp, two resistors, and a capacitor. The capacitance is 2.0 \( \mu \text{F} \).
5 (25 pts)
(a) (7 pts) The circuit is an integrate circuit. Derive $v_{out}(t)$. $R_S=10\,\text{k}\Omega$, $C_F=0.008\,\mu\text{F}$.
(b) (5 pts) If the input signal $v_{in}=\sin(2000\pi t)\,\text{V}$, calculate $v_{out}(t)$ and the peak amplitude.
(c) (3 pts) If the input signal $v_{in}=10\,\text{mV}$, calculate $v_{out}(t)$ and $v_{out}(t=100\,\text{ms})$.
(d) (3 pts) Op-amp is saturated when the output voltage reach the power supply voltage, $\pm 15\text{V}$ in this case. At what time does the integration of the DC input cause the op-amp to saturated fully?
(f) (7 pts) If the input signal is now $v_{in}=0.01+\sin(2000\pi t)\,\text{V}$, describe what happens to the output waveform till the op-amp is fully saturated.
6 (15pts) Design a 3 bit counter using D-FF to count up all odd numbers, i.e.
1→3→5→7→1→3….. To optimize the design, you are allowed to reset other even
number states into any one of these odd number states. At the end, indicate where those
even number states will be reset into.