Exam 2

Physics 181, Friday Nov 17 1-2:30

You may use a 3"x5" card of notes, both sides. NO PHONES.

Present *clear* and *complete* answers.

Unjustified answers will earn no points. Any person who has taken this class should be able to understand what you did just by reading your solution. A diagram and a few words usually help. Start calculations with definitions (*e.g.* $\vec{v} \equiv \frac{d\vec{r}}{dt}$), facts (*e.g.* Newton's laws), or commonly used equations (*e.g.* constant acceleration equations).

1. From an oscilloscope trace of $v_{in}(t)$ and $v_{out}(t)$, calculate the

   (a) amplitude of the gain, $|G|$ and
   (b) phase shift $\Delta\phi$ (take care with the sign!)

   You will be given an actual screenshot. Provide actual numerical values, plus uncertainties.

2. From an oscilloscope trace, write the expression for an oscillating voltage in the form

$$v(t) = v_0 \sin(\omega t + \phi_0) + v_{\text{offset}}$$

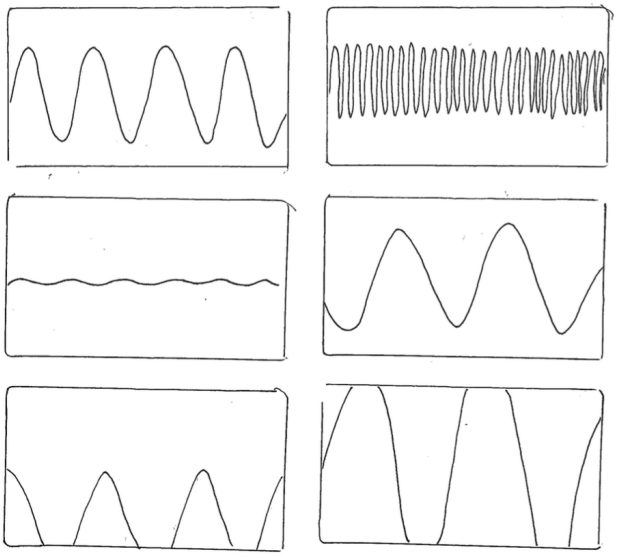
   You will be given an actual screenshot. Provide actual numerical values, plus uncertainties.

3. You're trying to measure a voltage signal on an oscilloscope. You see a reasonable trace,

   (a) but it's constantly moving. What's likely wrong and how do you fix it? Give specific instructions. "Autoset" or "Run/Stop" are not acceptable answers.

   (b) but the measure function says you have a 84Vpp signal. You're pretty sure it's less than 10Vpp. What might be wrong and how do you fix it? Give specific instructions.

   (c) but you can use the scale knobs to change the display. Which of the the following traces (of the same signal!) are most appropriate for measuring the peak to peak voltage? the period? Why are the others not appropriate?



4. When plotting data or theoretical behavior, we can use either a linear or a logarithmic scale.

   When is it effective to use a logarithmic scale? a linear scale? Provide examples.

5. For a circuit consisting of a combination of resistors, inductors and capacitors, determine the

   (a) gain $G(\omega)$
   (b) amplitude of the gain $|G(\omega)|$
   (c) phase of the gain $\phi(\omega)$
   (d) values of $|G|$ and ϕ in the limit of high and low frequencies.

6. What are the characteristics of a high-pass filter? low pass filter? bandpass filter?

   Don't describe the components. Describe the *behavior* or *frequency response.*

7. Here are some common filters:

   RC high-pass filter
   RC low-pass filter
   series RLC circuit
   RC bandpass filter

   (a) Draw circuit diagrams for each of the above. Include input and output terminals.
   (b) Determine and calculate the characteristic frequency for each of the above.
   (c) Determine the values of $|G|$ and ϕ at the characteristic frequencies.

8. (a) Derive the expression for the impedance of a capacitor,

$$Z_C = \frac{1}{j\omega C}.$$

   Start from the definition of current and capacitance, $i = dq/dt$ and $C = Q/V$

   (b) Derive the expression for the impedance of an inductor,

$$Z_L = j\omega L.$$

   Start with the expression for voltage for an inductor $V = Ldi/dt$.

9. (a) Show that the output impedance of a voltage divider, made of two components Z_1 and Z_2 where the output is taken over Z_2, is

$$Z_{out} = \frac{Z_1 Z_2}{Z_1 + Z_2}$$

   (b) Use the above to calculate the output impedance of any RC, RL, or RLC circuit.

   (c) How are the output impedance and the Thevenin equivalent impedance related?

10. Calculate a circuit's input impedance.

11. What are preferred values for input and output impedances?

    Explain why these are preferred, and what happens if they're not followed. Include a specific example.