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## Homework Set #5

### Physics 3500/8800

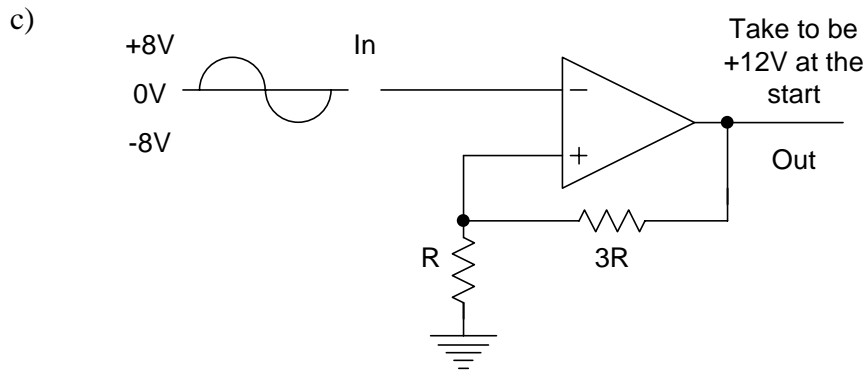
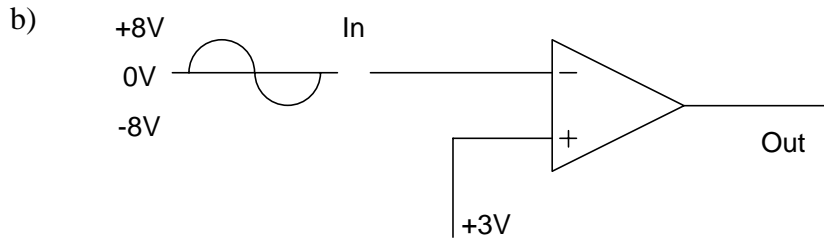
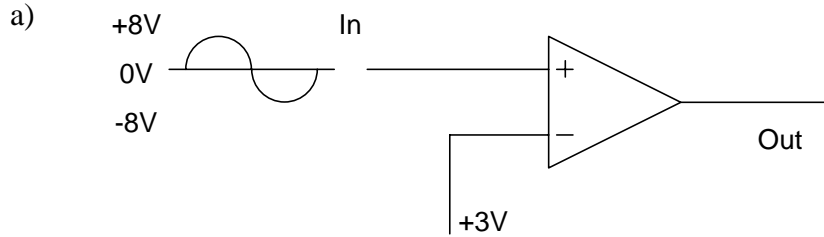
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1. State the *two main* characteristics of ideal operational amplifiers.
2. Use the characteristics referred to in (1) to deduce the following:
  - a)  $V_+ \approx V_-$  (for *linear* operations)
  - b)  $I_{in} \approx 0$  (current into amplifier)
3. Sketch the standard *inverting* configuration, and *derive* the expression for the gain using the results in (2).
4. Sketch the standard *non-inverting* configuration, and derive the expression for the gain.
5. Sketch the *differential* configuration, and derive the relation between the *output* and the two *inputs*.
6. Using *no more than 2* amplifiers, design an op. amp. circuit to combine the three *variable* input voltages  $V_1$ ,  $V_2$ , and  $V_3$  with the *constant* voltage +12 to get the following result:

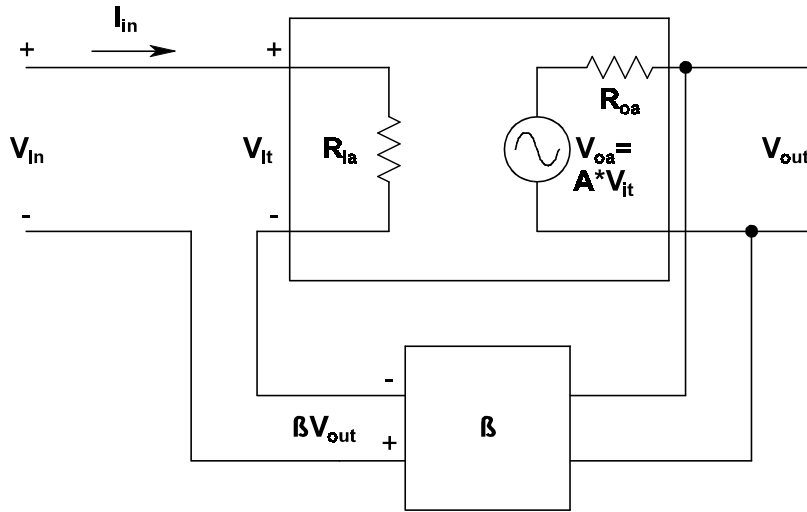
$$V_o = 3V_1 - 6V_2 + V_3 - 5$$

7. Sketch the configuration for using an op. amp as a *voltage comparator*, and explain its use.
8. Sketch the configuration for using an op. amp as a *Schmitt Trigger*, and explain the operation of the circuit. Explain what is meant by *hysteresis*.

9. Predict the outputs for the following:



10. Consider the amplifier with feedback as sketched below (the +'s and -'s represent the



standard sign convention for the input loop):

a) For the open-loop Amplification factor A, show that the ratio

$$G = \frac{V_{out}}{V_{in}} = \frac{A}{1 - \beta A}$$

b) Show that the effective input resistance of the system as shown is

$$R_{in} = \frac{V_{in}}{I_{in}} = R_{ia} (1 - \beta A)$$

- c) Show that the effective output resistance of the system as shown is

$$R_o = \frac{V_{\text{out, open}}}{I_{\text{out, short}}} = \frac{R_{\text{oa}}}{1 - \beta A}$$

11. Sketch the non-inverting op. amp. amplifier circuit, identify the feedback fraction  $\beta$  in terms of the R's, and show that the exact output is given by

$$G = \frac{V_{\text{out}}}{V_{\text{in}}} = \frac{A}{1 + \frac{AR_1}{R_1 + R_2}}$$

Show also that this exact result reduces to the one derived earlier for the case  $A \rightarrow \infty$ .