

## Ministry of Higher Education <br> 

Electrical Engineering Department


وزارة التـــــــيم المــــــي
جامعة الملك فهر للبنرولـوالمعادن
قسـم الهندسـة الكهربائيــة

EE 445-072<br>Instructor: Dr. Alaa El-Din Hussein

## Assignment \# 3

Due Date: Saturday April 5, 2008 (in class)

## Question 1:

## For the shown instumentional amplifier:

a) What are the voltage at the inverting terminals of opamps 1 and 2.
b) Use those voltages to find the voltages at the output of opamps 1 and $2, \mathrm{~V}_{\text {ol }}$ and $\mathrm{V}_{\mathrm{o} 2}$ respectively.
c) For op amp 3, find $V_{o}$ in terms of $V_{o 1}$ for $V_{o 2}$ grounded. What op amp configuration is this?
d) For op amp 3, find $\mathrm{V}_{\mathrm{o}}$ in terms of $\mathrm{V}_{\mathrm{o} 2}$ for $\mathrm{V}_{\mathrm{o} 1}$ grounded. What opamp configuration does this resemble?
e) By superposition, the total output $\mathrm{V}_{\mathrm{o}}$ of opamp 3 is the sum of the above two results. Find the complete input/output relationship of opamp 3. Using that relationship and the values of Vo1 and Vo2 found above, find Vo in terms of $\mathrm{V}_{1}$ and $\mathrm{V}_{2}$.


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## Question 2:

Solve the following differential equation using opamp integrators and adder/subtractor. $\frac{d^{2} y}{d t^{2}}+5 \frac{d y}{d t}+2 y=2 \sin (2000 \pi t)$ assuming that $\mathrm{y}(0)=0$; and $\left.\frac{d y}{d t}\right|_{t=0}=-1$, and a sinusoidal source of frequency 1 KHz is available.

## Question 3:

Draw the waveform at $\mathrm{V}_{\text {out }}$ and $\mathrm{V}_{\mathrm{f}}$, and drive an expression for the frequency of oscillation.


## Question 4:

Design a circuit to perform the following operation: $y(t)=3 * x(t)^{2}$


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