Circuits

1. 7 points
   For the following circuit the op-amp is ideal.
   a) Set up the differential equation for $v_o(t)$ versus $v_i(t)$.
   b) Give the voltage transfer function $V_o(s)/V_i(s)$.
   c) Give the impulse response, $v_o(t)$ for $v_i(t) = \delta(t)$.

   ![Circuit Diagram]

2. 7 points
   The following circuit has $i_D = 10^{-3}(v_{GS} - 1)^2$, $V_{DD} = 8V$, $V_G = 5V$ and $v_i$ much smaller than 5V in magnitude.
   a) Give the value of $i_D$ for $v_i = 0$.
   b) Find the range of values of $R$ such that $V_0 \leq V_0 \leq 1$ (assuming $v_i = 0$).
   c) Use $V_{DD}$ and two resistors, $R_1$ & $R_2$, to replace $V_G$. Draw the new circuit and give some values for $R_1$ & $R_2$; show how $v_i$ is coupled in.

   ![Circuit Diagram]

3. 6 points
   For the following circuit the diodes are ideal ($i = 0$ for $v < 0$ and $v = 0$ for $i > 0$).
   Assume that $v_i(t) = 2\sin(2t)$ for $0 \leq t$ and that at $t=0$ the equal positive capacitors are uncharged.
   a) Give $v_C(0^+)$.
   b) Sketch $v_C(t)$ and $v_o(t)$ for two periods of $v_i(t)$.

   ![Circuit Diagram]
a. If the input voltage of the op-amp is \( v_i = 0 \) \( v_i = R_i + i\text{s}d/dt \) and \( C\frac{dv_i}{dt} = -i\text{c} \) (both currents left to right) and as the input current to the op-amp \( = 0 \Rightarrow i_r = i_c \Rightarrow v_c = -RC \frac{dv_i}{dt} = -\frac{1}{RC} (CDv_i/dt) \)

\[ a) \Rightarrow \frac{1}{LC} \frac{dv_i(t)}{dt} + RC \frac{dv_c(t)}{dt} = -v_c(t) \]

Let \( 2xv_i/dt = \left( \frac{1}{LC} a^2 + RC \right) v_i(t) = -\frac{-1}{C} (a+R) \)

\[ b) \Rightarrow \frac{v_i(t)}{v_i(t)} = -\frac{1}{LC} \frac{a^2 + RC}{a} = -\frac{1}{C a(C-a+R)} \]

\[ v_c(t) = \delta(t), v_i(t) = 1 \Rightarrow v_c(t) = \frac{1}{C} \frac{1}{a} \frac{a^2}{a^2 + RC} 1(t) \text{ where } 1(t) = \text{unit step} = \frac{1}{2} t > 0 \]

\[ c_2 \text{ for } v_i = 0, v_{ds} = V_D \Rightarrow i_D = 10^{-3} (5-1)^2 = 16 \times 10^{-3} \]

\[ a) \Rightarrow i_D = 16 \text{ mA} \]

\[ v_{ds} = V_D - R i_D = 8 - 16 \times 10^{-3} \Rightarrow v_{ds} - 1 = 7 \Rightarrow 7 \times 16 \times 10^{-3} > -4 \]

\[ b) \Rightarrow R \leq \frac{V_D}{16 \times 10^{-3}} = 0.125 \times 10^3 = 1250 \Omega \]

\[ c) \text{ large } \Rightarrow \text{ allows } v_i \text{ to connect except not impact } v_c \text{ since } \]

\[ \text{By voltage divides } \]

\[ \frac{3}{3} \]

\[ \text{Choose } R_1 \text{ large, such as } 5 \text{M} \Omega \Rightarrow R_2 = 3 \text{M} \Omega \]

\[ \text{at } t = \tau, v_c(0+) = 2 \text{ in } \tau = 0 \text{ appear on both } C \text{ as } \]

\[ a) v_c(0+) = 0 \]

\[ \text{For the first cycle } v_c(t) = v_i, v_i = v_c(t) \text{ or } v_c(t) \text{ and } 2 \text{ to } \]