Physics 536 - Assignment #6 - Due March 19$^{\text{th}}$

1. Fairchild Semiconductors manufactures the 1N916 small signal diode for which the reverse saturation current is specified as being $I_0 = 10^{-13}$ A. The maximum power that this type of diode can dissipate is specified to be 500 mW.

(a) From the equation

$$i = I_0(e^{eV/kT} - 1), \tag{1}$$

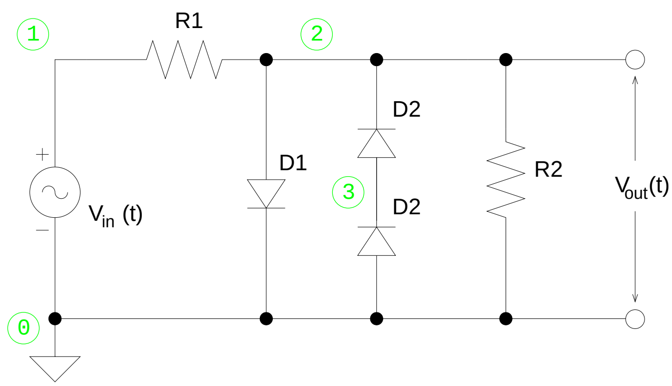
calculate the power dissipated by such a diode when it is conducting a current of 0.5 A at $T = 25°C$.

(b) Suppose the temperature of the diode increased to $T = 250°C$. Calculate the dissipated power at this higher temperature. Does this exceed the maximum power that the diode is capable of dissipating?

2. The SPICE model for the 1N916 diode is

```
.MODEL 1N916   D(IS=0.1P RS=8 CJO=1P TT=12N BV=100 IBV=0.1P)
```

Simulate the following circuit:



in which D1, D2 and D3 are type 1N916 diodes, $R1 = 100\ \Omega$, $R2 = 10\ \text{k}\Omega$ and $V_{in}(t)$ is a sinusoidal voltage source with a peak-to-peak amplitude of 2 V and a frequency of 10 kHz, which can be simulated using

```
VIN 1 0 DC 0 SIN(0 2V 10KHZ)
```

and a transient analysis specified using

```
.TRAN 1US 0.5MS 0 1US
```

to force SPICE to use a maximal time step of 1 μs.

Provide the SPICE netlist and a graph of the voltage at nodes 1 and 2. At approximately what positive and negative voltages does the output signal start to become limited by the diodes?

3. The SPICE model for a small signal n-channel JFET is

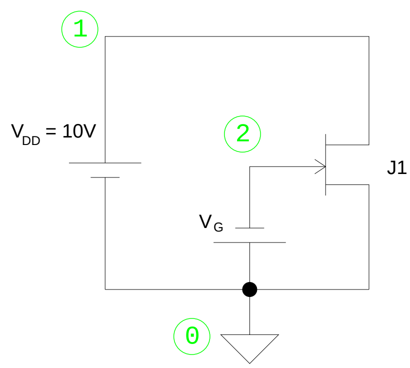
```
.MODEL MYJFET NJF(VTO=-3V IS=1NA BETA=0.001 CGS=2P CGD=2P)
```

which is used in a circuit using

```
Jx d g s MYJFET
```

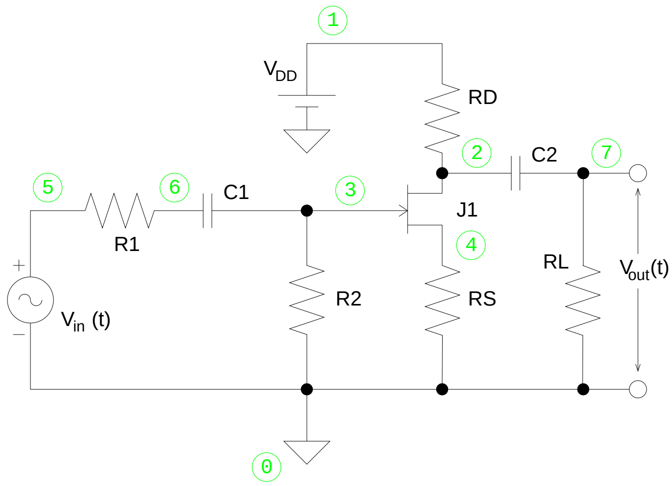
in which `d`, `g` and `s` are the node numbers of the drain, gate and source, respectively.

Using the following circuit:



perform a DC operating point analysis for $V_G = 0, 1, 2$ and 3 V, to generate a table of values for I_D as a function of V_{GS} for this JFET. What are the parameters I_{DSS} and V_P, that characterize this JFET?

4. Consider the following common source amplifier circuit:



in which $J1$ is to be modelled using

```
.MODEL ANOTHERJFET NJF(VTO=-4V IS=1NA BETA=0.00125 CGS=2P CGD=2P)
```

which has $I_{DSS} \approx 20$ mA and $V_P = -4$ V. The voltage source, $V_{in}(t)$ has a peak-to-peak amplitude of 10 mV and a frequency of 10 kHz, modelled using

```
VIN 5 0 DC 0 SIN(0 0.01V 10KHZ)
```

and where $R1 = 10$ kΩ represents the large output impedance of a non-ideal voltage source, such as the element of a microphone.

(a) Select a reasonable value for C_1 such that $R_1C_1 \gg 1/f$ where f is the frequency of the input voltage source.

(b) Calculate the voltage, V_{GS} that will result in a quiescent current of $I_0 = 10$ mA.

(c) What value of R_2 should be used to provide an input impedance impedance of 10 MΩ?

(d) Calculate the value of R_S that will result in the desired voltage V_{GS} when no input signal is present.

(e) Calculate the transconductancd, g_m, at the quiescent point.

(f) Calculate the value of R_D that will produce a voltage gain of $A_V = -5$ when $R_L = \infty$.

(g) Calculate the minimum acceptable voltage, V_{DD}, that will be needed for the JFET to be operating in the active region.

(h) What is the output impedance of the circuit? What value of the load resistance, R_L, will maximize the power transferred to the load?

(i) Hand in the netlist for this circuit, the output of the operating point analysis and a graph of the input and output waveforms.

(j) Simulate the circuit with $R_2 = 1$ GΩ. Why does the circuit now fail to operate as desired?