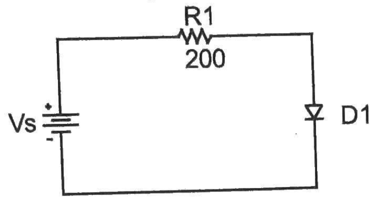
ECSE-2050

Introduction to Electronics
Summer 2020 **Name** ______________________

Homework 8

Reading: 2.7-8, (Chapter 3 concepts), 4.1-3

Problem 1) Diodes, bias point analysis
For all diodes in this section, the thermal voltage, V_{th}, is 26mV, the reverse saturation current, IS, is 1E-12 A and the non-ideality factor, n, is 1.



I use a python script for these problems

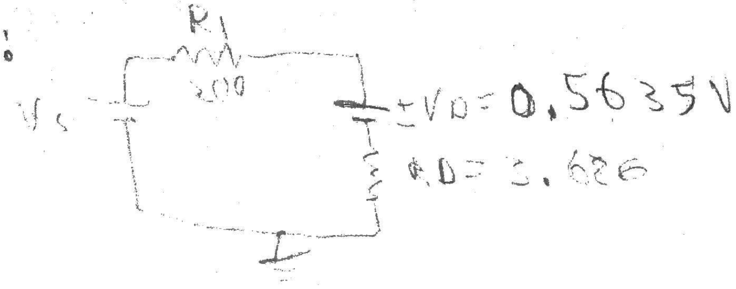
a) For Vs = 2V, find the DC bias point of the above diode
   a. Guess a diode voltage of 0.5V (no work necessary for this step).
   b. Use KVL and Ohm's Law to find the current through the resistor (equal to the current through the diode).
   c. Use the diode equation to find a diode voltage, based on the part b diode current.
   83.605 Ω ← d. Repeat parts b and c, until three significant digits are reached (the first three significant digits are not changing with each iteration).
   0.007/(0.026) = gD = e. Based on the bias point, determine the diode conductance g_D. ≈ 0.271
   gD = 0.271
   f. Using the slope of the tangent line (g_D), the DC bias point voltage and current, determine the tangent line intercept, V_{Do}, on the x-axis (voltage axis). y = mx + b b = -.1528 V_D = 0.5635
   g. Determine the linear equivalent circuit model for the diode, $r_D = 1/g_D$, in series with V_{Do}. Draw the equivalent circuit. next page

   (At this point, you may want to make script for this. I use a Matlab script, but you can probably set one up on your calculator.)

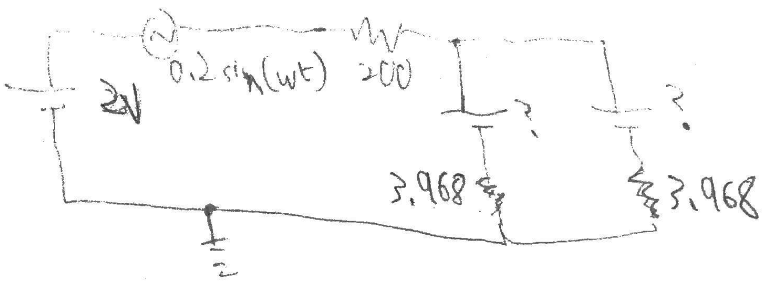
b) Repeat the above process for Vs = 2.05V and Vs = 1.95 V.
   Vs = 2V R = 83.605
   Vs = 2.05V R = 80.914
   Vs = 1.95V R = 86.485
   a. We can estimate the inverse of the slope of the diode curve using difference approximations, $\frac{1}{m} = \frac{\Delta V_D}{\Delta I_D}$. If a linear approximation is valid for the source varying 1.95V to 2.05V, then the slope calculations of the diode curve for source voltages Vs = 2V,2.05V and Vs = 1.95V,2V will be close in value. For a 100mV variation in source voltage, is a linear approximation of the diode curve valid?
   Yes it can be a good approximation.

c) Repeat the above process for Vs = 2.5V and Vs = 1.5 V.
   Vs = 2V R = 83.605
   Vs = 2.5V R = 62.795
   Vs = 1.5V R = 125.565
   a. We can estimate the inverse of the slope of the diode curve using difference approximations, $\frac{1}{m} = \frac{\Delta V_D}{\Delta I_D}$. If a linear approximation is valid for the source varying 1.5V to 2.5V, then the slope calculations of the diode curve for source voltages Vs = 2V,2.5V and Vs = 1.5V,2V will be close in value. For a 1V variation in source voltage, is a linear approximation of the diode curve valid?
   It is not a good approximation

1AG:



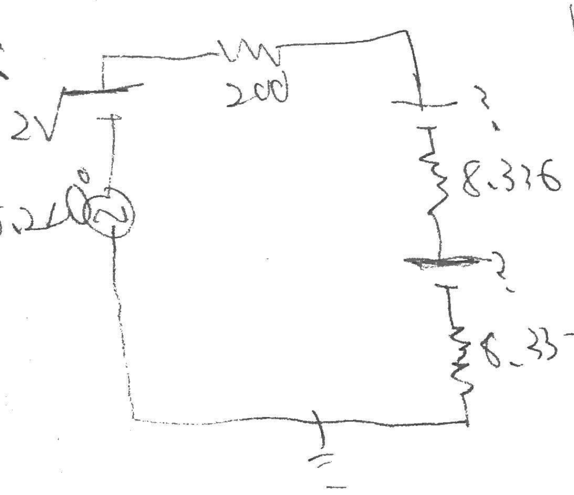
2D:



2E: $Y = mx + b$ $b = -0.167$ $V_{D0} = 0.663$

Ac: $\frac{0.2 \cdot 1.984}{200 + 1.984} = 0.00196 \cdot \sin(wt)$ $V_D = 0.00196 \sin(wt) + 0.663$

2J:



2K: $y = mx + b$ $b = -0.794$

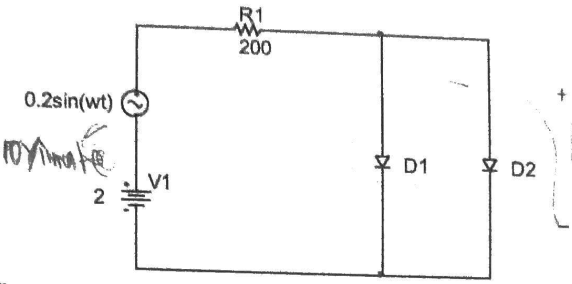
$V_{D0} = 0.6621\ V$

Ac: $\frac{0.2(8.336 \times 2)}{8.336 \times 2 + 200} = 0.015 \sin(wt)$

$V_D = 0.6621V + 0.015 \sin(wt)$

2) Diodes, breakpoint analysis
For all diodes in this section, the thermal voltage, V_{th}, is 26mV, the reverse saturation current, IS, is 1E-14 and the identity factor, n, is 1.
(Again, you are encouraged to use a script for determining the DC bias points.)

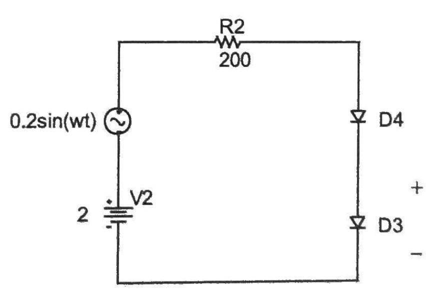
linear approximate



load

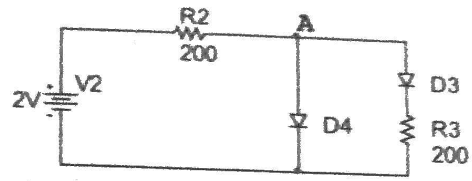
105.2 Ω — a) To three significant digits, determine the DC bias characteristics of the above diodes. (In this circuit, what is the relationship between current through a single diode and the resistor current?). Guess 0.5V

b) Determine the conductance of the diodes, g_D. = 0.232
c) Determine the resistance of the diodes, r_D. = 3.968
d) Redraw the circuit, replacing the diodes with the equivalent linear circuit of a diode resistance and a DC source.
e) Use superposition analysis to find the small signal AC component of the diode voltage.
f) For the amplitude of the AC signal, is the linear approximation of the diode reasonable? Yes it is reasonable



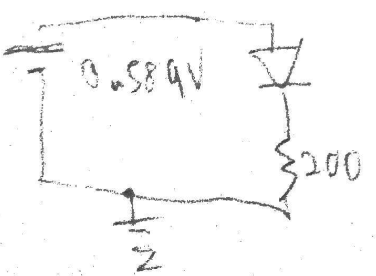
220.6 Ω — g) To three significant digits, determine the DC bias characteristics of the above diodes. (In this circuit, KVL includes two diodes when estimating the resistor voltage.) guess 0.5V
h) Determine the conductance of the diodes, g_D. = 0.1200
i) Determine the resistance of the diodes, r_D. = 8.336
j) Redraw the circuit, replacing the diodes with the equivalent linear circuit of a diode resistance and a DC source.
k) Use superposition analysis to find the small signal AC component of the diode voltage.
l) For the amplitude of the AC signal, is the linear approximation of the diode reasonable? Yes it is reasonable.

Problem 3) Parallel diodes – bias point analysis
For all diodes in this section, the thermal voltage, V_{th}, is 26mV, the reverse saturation current, IS, is 1E-12 and the identity factor, n, is 1.



a) When considering the above circuit, what can we say about the voltage of D4 relative to the voltage of D3. $V_{D4} = V_{D3} + V_{R3}$
b) Noting that a small change of diode voltage corresponds to a large change in diode current, is the current in D4 much larger or much smaller than the current in D3? much larger
c) Given your part b answer, what approximation is reasonable when applying KCL at node A? No current through D3
d) When considering all of the above, is it reasonable to assume the voltage across D4 is approximately equal to the voltage calculated in problem 1? Yes
e) Using your problem 1 result as the voltage across D3 and R3, find the DC bias point for diode D3. Guess 0.5V
f) Using your DC bias current through diode D3 and the assumed DC bias voltage across D4, apply KCL at node A to get a 'better' approximation of the DC bias current through D4. Apply the iterative step to get a new approximation of the voltage across D4. Did the voltage change significantly? Were the part a-d approximations reasonable?
g) Would the method used to approximate the diode bias points still be valid if R3 were significantly larger (eg., ~20kΩ)? Yes. Larger difference in V and I
h) Would the method used to approximate the diode bias points still be valid if R3 were significantly smaller (eg., ~22Ω)? No, diodes are virtually equal in parallel.
i) Redraw the circuit, replacing the diodes with the equivalent linear circuit of a diode resistance and a DC source.
j) If an AC source was placed in series with the DC source, approximately determine the variation in the source current.

3E:

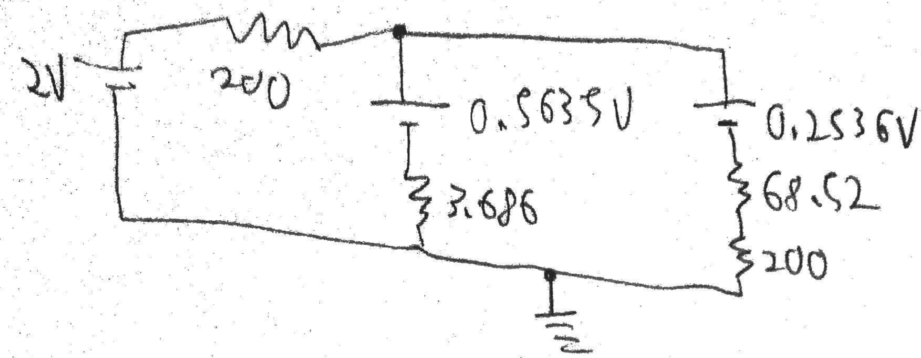


DC Bias = 1353.58 Ω

3F: $\frac{V_a - 2}{200} = \frac{V_a - V_{DC}}{3.686} + \frac{V_a - V_{D03}}{200 + 68.52}$ $V_a = 0.5326\,V$

Voltage did not change significantly.
Reasonable approximations

3 I:



3 J: ignore D3/R3. $AC = V_0 \sin(\omega t)$

Variation: $\dfrac{(2V + V_0) - 0.5635V}{200 + 3.686} \rightleftarrows \dfrac{(2V - V_0) - 0.5635V}{200 + 3.686}$

$$\frac{(2V \pm V_0) - 0.5635V}{200 + 3.686}$$

```python
#Code written by Saaif Ahmed
#IE HW 8 Problem 1/3 code
import math
vs = 0.5895
vd = 0.5
r = 200
Is = 10**(-12)
n = 1
vtherm = 26/1000
ir1 = 0

count = 0
while count < 10:
    print(vd)
    vr = vs - vd
    ir1 = vr/r
    vd = n * vtherm * math.log(ir1/Is)

    count+=1
print("current:",ir1)
print("voltage: ",vd)
print("DC bias: ",vd/ir1)
print("gD: ", ir1/(n*vtherm))
print("rD: ", (n*vtherm)/ir1)
```

```
#Code written by Saaif Ahmed
#IE HW 8 Problem 2 code
import math
vs = 2.0
vd = 0.5
r = 200
Is = 10**(-14)
n = 1
vtherm = 26/1000


count = 0
while count < 10:
    print(vd)
    #vr = vs - vd
    vr = vs - (vd + vd)
    ir1 = vr/r
    #vd = n * vtherm * math.log((ir1/2)/Is)
    vd = n * vtherm * math.log(ir1/Is)
    count+=1
print("current:",ir1)
print("voltage: ",vd)
print("DC bias: ",vd/ir1)
print("gD: ", ir1/(n*vtherm))
print("rD: ", (n*vtherm)/ir1)
```