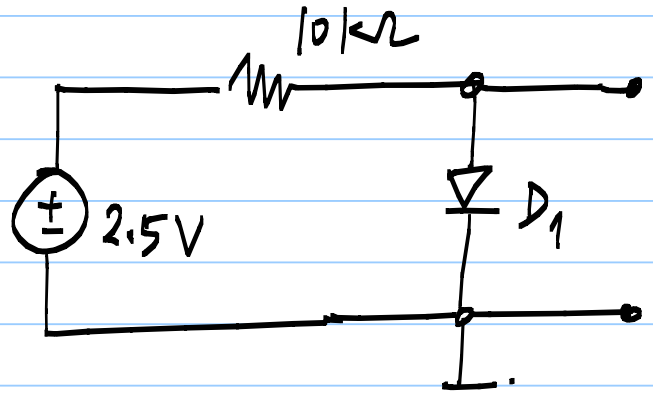
Using SPICE-like simulators for circuit analysis

Note Title 3/9/2011

Example circuit:

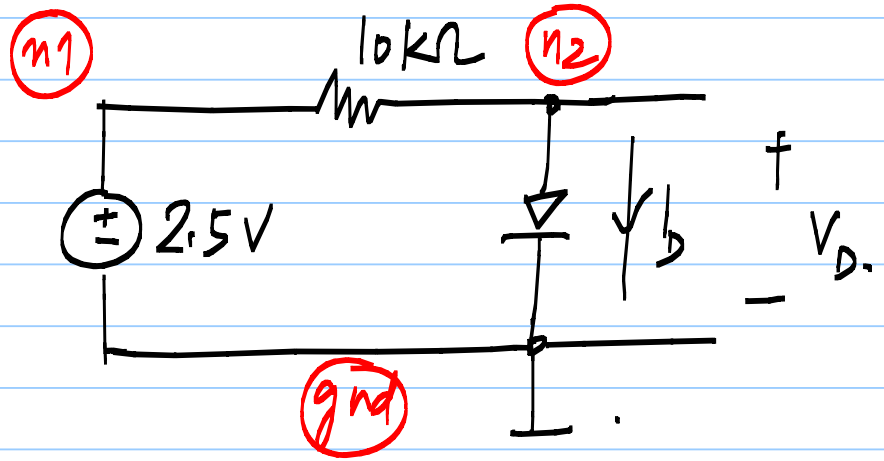


D_1: "ideal_diode"

Analysis that one would like to do:

* Operating point (DC)
* Small signal incremental analysis (AC)
* Analysis with large time varying signals (transient)

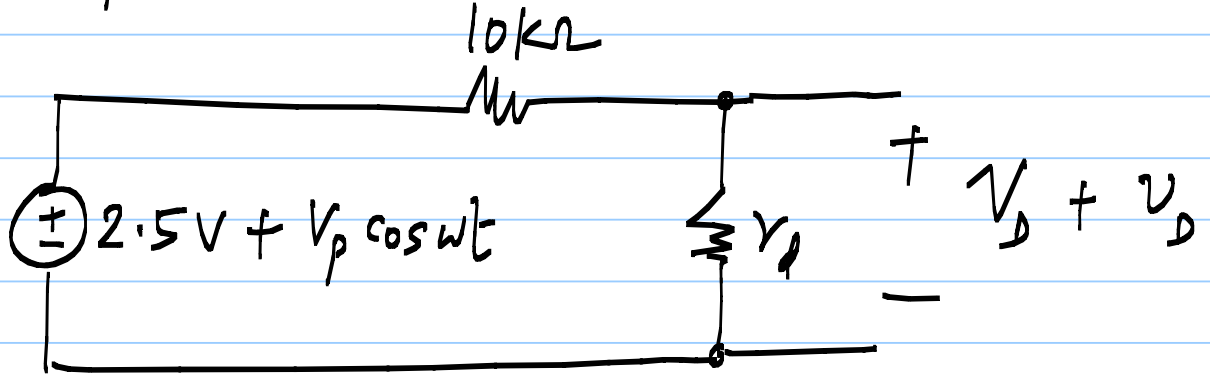
DC operating point analysis:



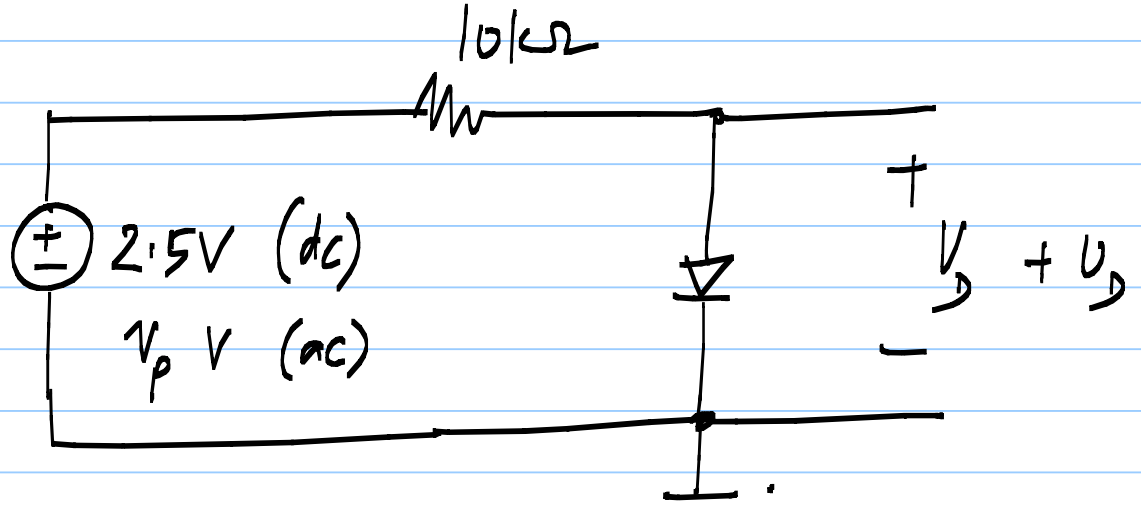
* Do .op analysis & determine V_D, I_D

Small signal incremental analysis:
(Hand calculation)

* Determine the small signal equivalent of the diode.
* Analyze the circuit below.



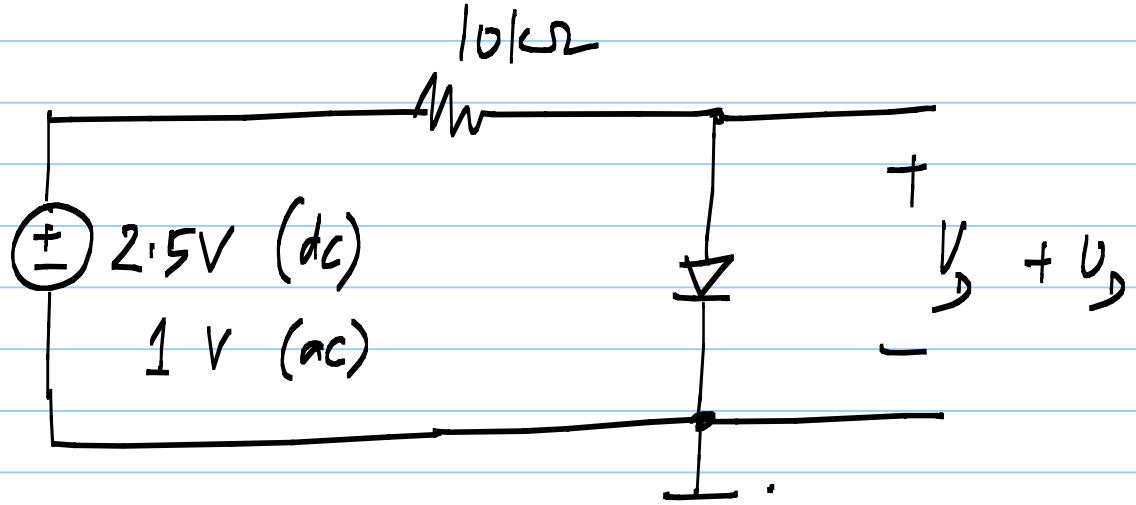
Small signal incremental analysis (simulation)



Compare results to hand calculations

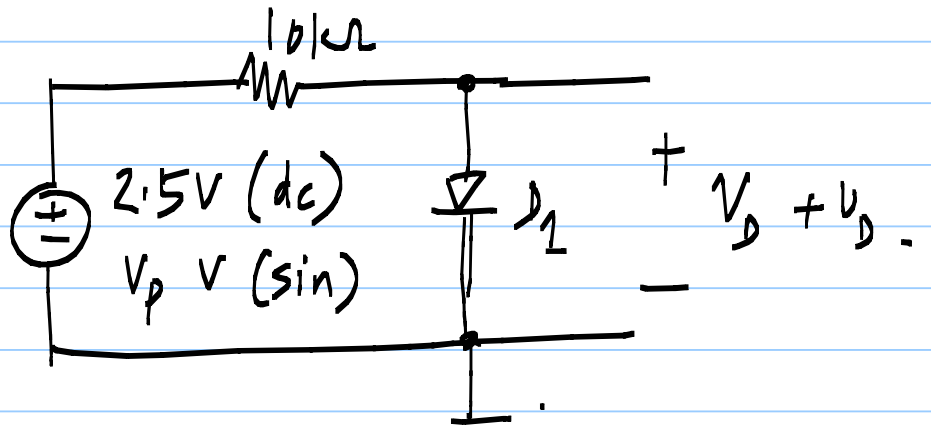
* Do .op & .ac analyses & determine V_D & v_D
* Can do .ac over a range of frequencies.
* What happens if V_p (ac magnitude) is changed?

Small signal incremental analysis (simulation)



* common to use 1V (ac)
* The ac part of the output is the "transfer function" from the input to the output

Large signal analysis with time varying signals



Transient analysis: Can't do by hand - this is why we use a simulator

* Use a small V_p (~ 10mV) and do transient analysis.
* Increase the amplitude and see what happens to the output increment.

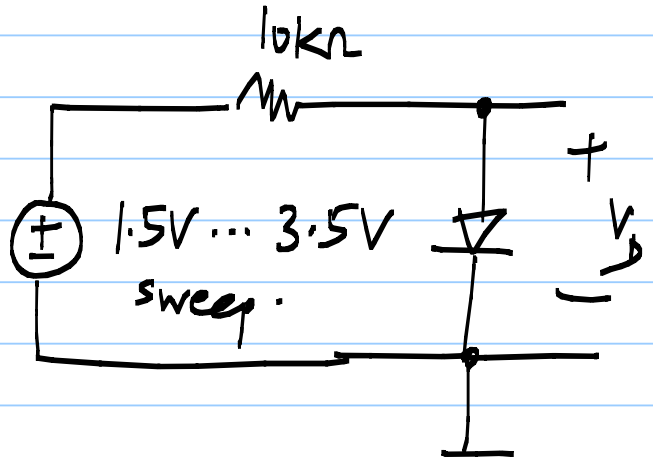
Basic analyses available in SPICE like simulators:

* DC analysis – operating point
* AC analysis – small signal incremental (linear) analysis over the operating point. Also for transfer functions
* TRAN (transient) analysis – Full solution to nonlinear differential equations of the circuit.

Can do all of them in a single run

Other features of a simulator:

* DC sweep: DO dc operating points at multiple input values. Can be used to determine nonlinear input-output (dc) relationships.



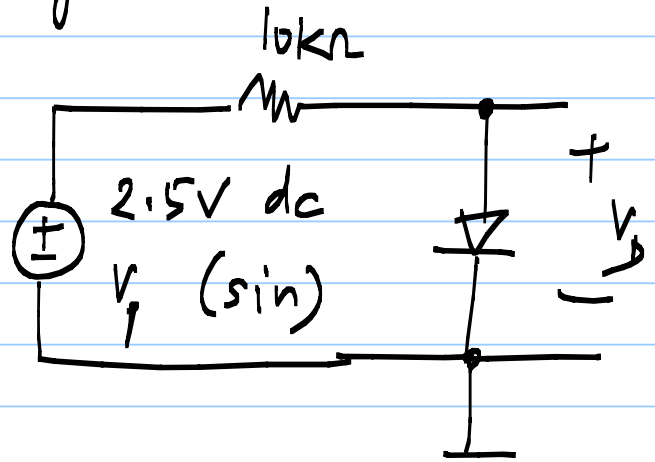
plot V_D vs. V_{in}

plot I_D vs. V_D

Other features of a simulator:

* Parametric sweep: Can do analyses for different component values.

e.g.:

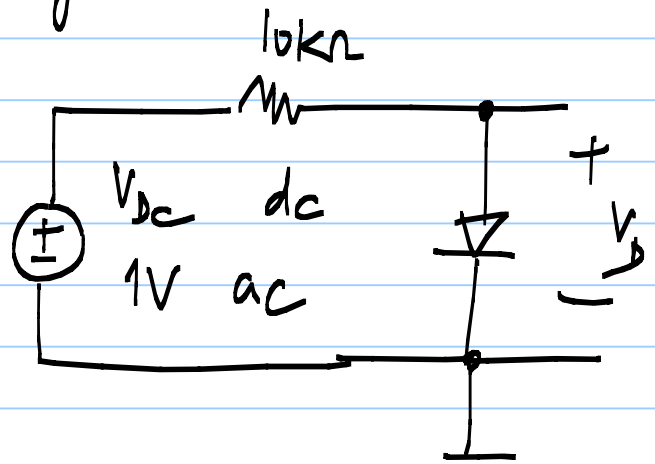


Sweep V_p from 10mV to 1V in decade steps & do transient analysis

Other features of a simulator:

* Parametric sweep: Can do analyses for different component values.

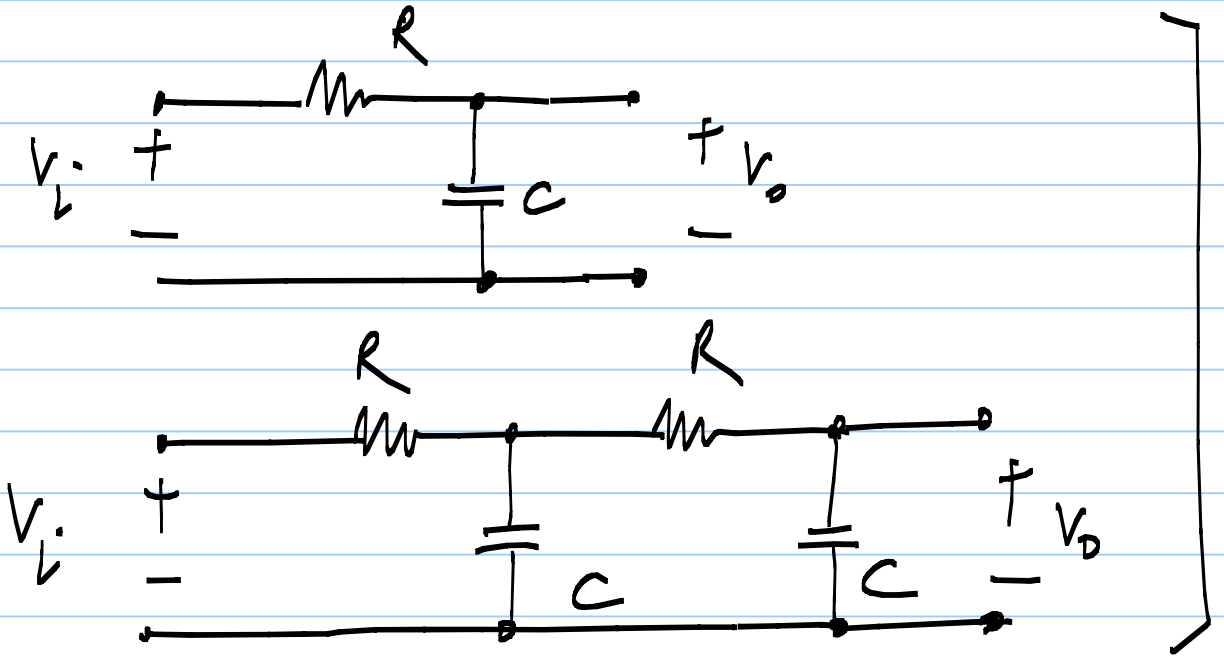
e.g.:



Sweep V_{DC} from 1V to 3V in 1V steps & do ac analysis

Other exercises:

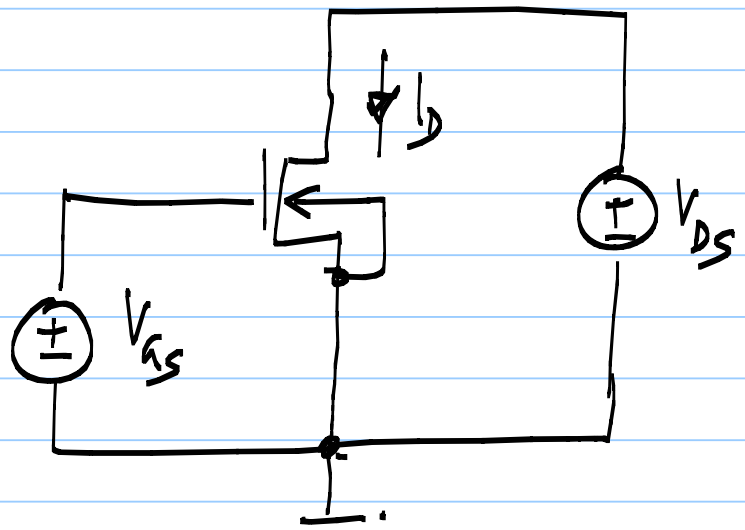
ac analysis for transfer functions:



Plot

$\left|\frac{V_o}{V_i}\right|$, $\not\propto \frac{V_o}{V_i}$

Transistor characteristics:



* Plot I_D vs. V_{DS} for different values of V_{GS}
* Try $\frac{W}{L} = \frac{1.8\mu}{0.18\mu}, \frac{3.6\mu}{0.36\mu}, \frac{5.4\mu}{0.54\mu}, \frac{7.2\mu}{0.72\mu}$
* Estimate μC_{ox}, V_t