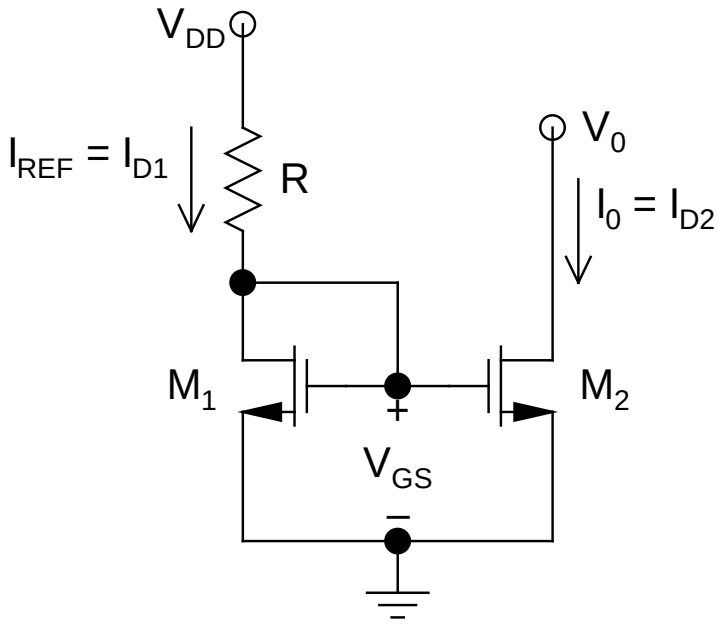
- ***Simple NMOS CM***:
  - $V_{GS1} = V_{GS2} = V_{GS}$
  - M_1 has its ***D and G shorted*** $\Rightarrow V_{GD1} = 0$
    $\Rightarrow$ ***always in saturation***, since $V_{DS1} > V_{GT1}$
    $\Rightarrow$ Known as ***diode-connected MOSFET***



  - Even though $I_G = 0$, the analysis is slightly more cumbersome than simple BJT CM

- ***In general, for NMOS (PMOS), the B terminal is always connected to the most negative (positive) potential available in the circuit to ensure that SB and DB junctions never get forward biased***
- ***Both M_1 and M_2 have their B terminals grounded*** $\Rightarrow V_{SB1} = V_{SB2} = 0$
  - $V_{TN1} = V_{TN01}$ and $V_{TN2} = V_{TN02}$
- Thus:

$$I_{REF} = I_{D1} = \frac{k'_{N1}}{2}\left(\frac{W}{L}\right)_1 \left(V_{GS} - V_{TN01}\right)^2$$

- For a ***given V_{DD} and R***, the equation has ***2 unknowns***: I_{D1} and V_{GS}
- Need ***another equation*** for ***unique solution***, which is the ***load line equation***:

  $I_{D1} = (V_{DD} - V_{GS})/R$
- ***Simultaneous solution*** of these ***two equations*** would give a ***unique solution*** for I_{D1} and V_{GS}
  - ***Caution***: ***2 roots, out of which, one will be unphysical***
- So far, we have ***neglected CLM***, which we would include soon!

- Now:

$$V_{GS} = V_{TN01} + \sqrt{\frac{2I_{REF}}{k'_{N1}\left(W/L\right)_1}} = V_{TN02} + \sqrt{\frac{2I_0}{k'_{N2}\left(W/L\right)_2}}$$

- Thus:

$$I_0 = \frac{k'_{N2}\left(W/L\right)_2}{2}\left[\left(V_{TN01} - V_{TN02}\right) + \sqrt{\frac{2I_{REF}}{k'_{N1}\left(W/L\right)_1}}\right]^2$$

- This is the ***exact expression*** of I_0, ***without making any assumptions/approximations whatsoever***

- Now, if $V_{TN01} = V_{TN02} = V_{TN0}$, and $k'_{N1} = k'_{N2} = k'_N$:

$$I_0 = \frac{(W/L)_2}{(W/L)_1} I_{REF}$$

- ***Very similar*** to BJT CM, but with a ***big exception***:
  - ***In BJT CM, this ratio could only be an integer***
  - ***In MOS CM, no such restriction exists***: ***$(W/L)_2$ can be >, =, or < $(W/L)_1$ $\Rightarrow$ any arbitrary current ratio can be obtained***

- Finally, if $(W/L)_2 = (W/L)_1$:

  $I_0 = I_{REF} \Rightarrow$ ***Current Mirror***!

- Two MOSFETs are deemed to constitute a ***matched pair***, if they have ***same*** V_{TN0}, γ, ϕ_F, λ, and k'_N
  - Note that all of these are ***process parameters***
  - ***(W/L) is NOT a process parameter***, since it's under ***designer's control***
  - ***If (W/L)s are also same, then the pair is known as perfectly matched***