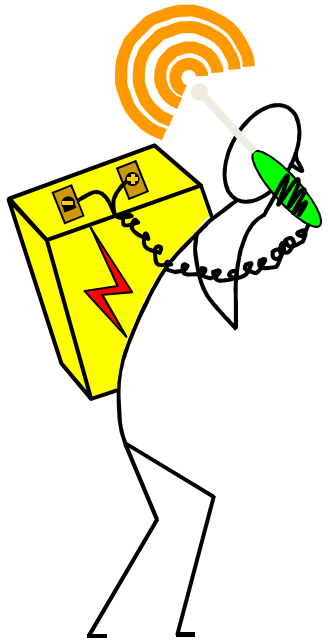
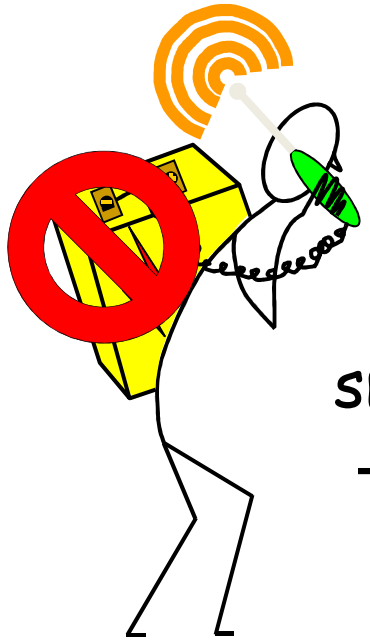
6.002x CIRCUITS AND ELECTRONICS

Energy and Power



Why worry about energy?

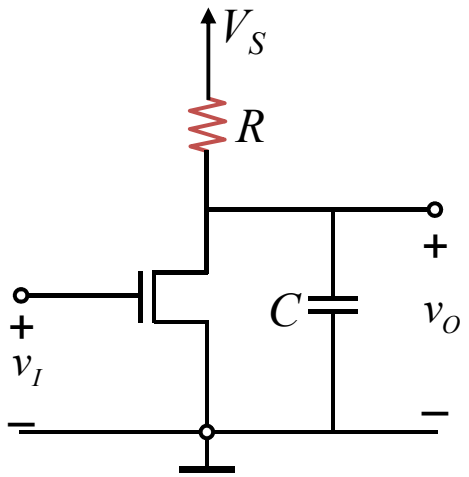


small batteries
→ good

Today:

- How long will the battery last?
  - in standby mode
  - in active use
- Will the chip overheat and self-destruct?
- Did you know, data centers in the US consume as much energy as the entire state of Utah!

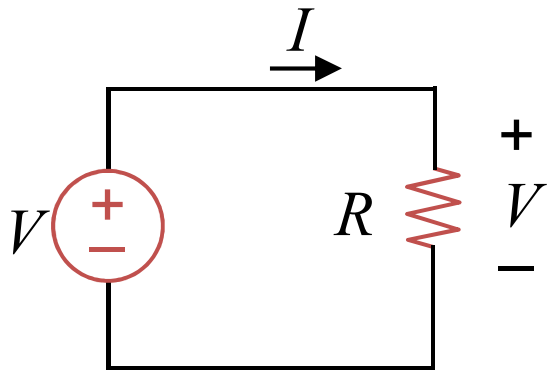
Look at energy dissipation in MOSFET gates



C: wiring capacitance and C_{GS} of following gate

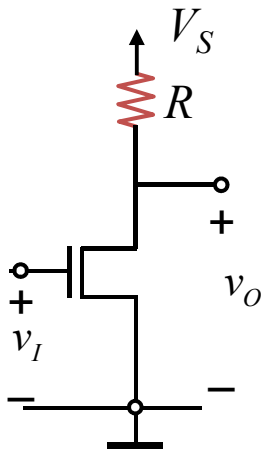
Example 1:

Example 1:



Static power for our gate

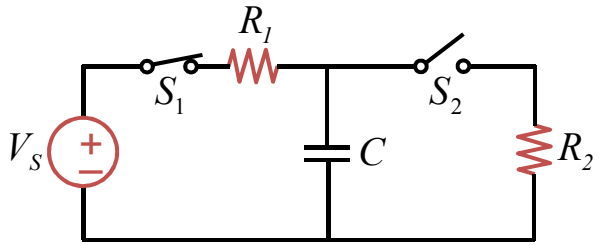
I.e., when the gate is not switching

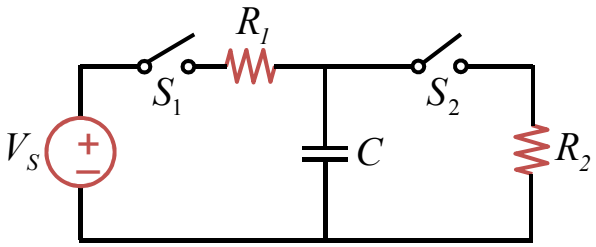


Example 2:

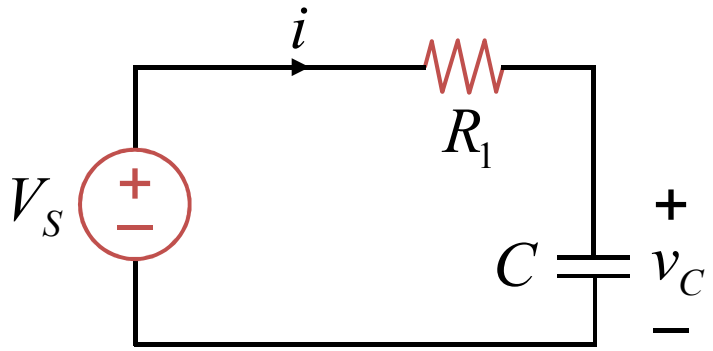


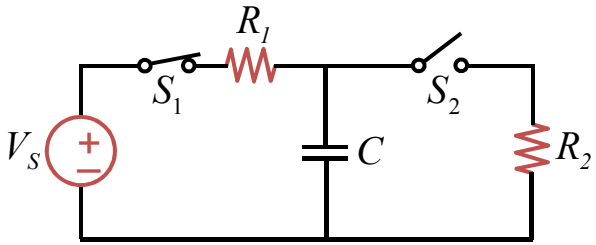
T_1 : S_1 closed, S_2 open

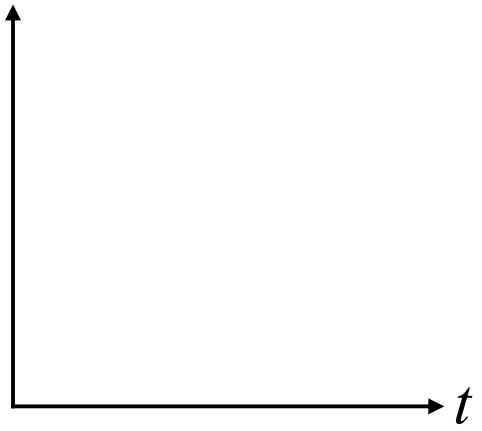


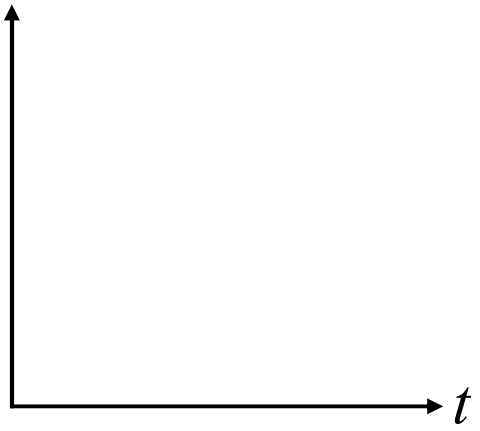


T_1 : S_1 closed, S_2 open

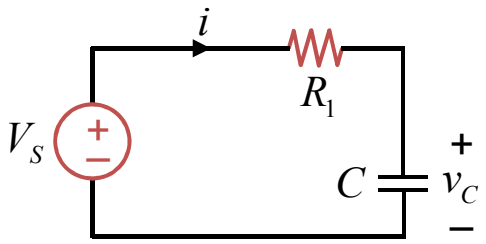




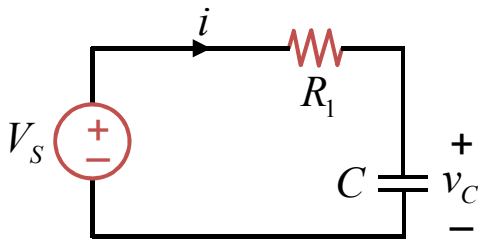




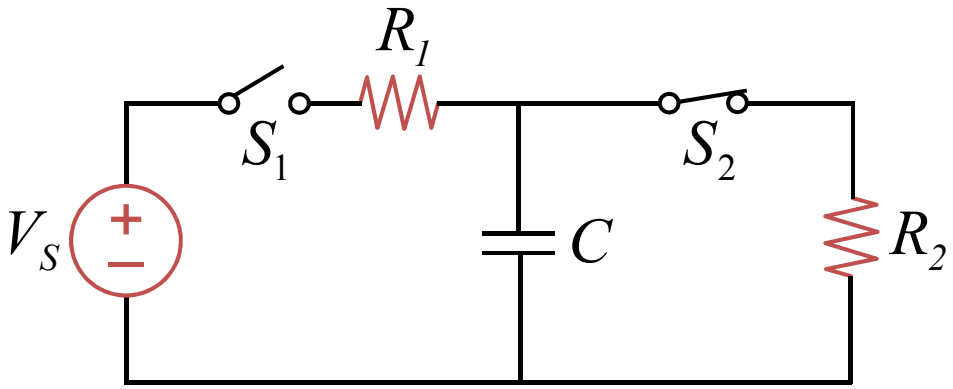
Total energy provided by source during T_1

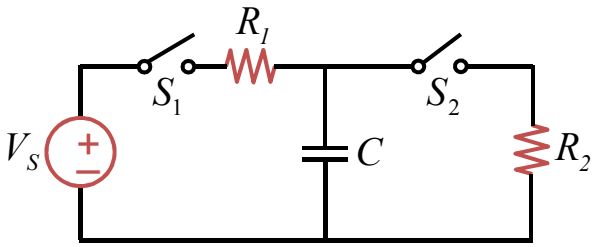


Total energy provided by source during T_1

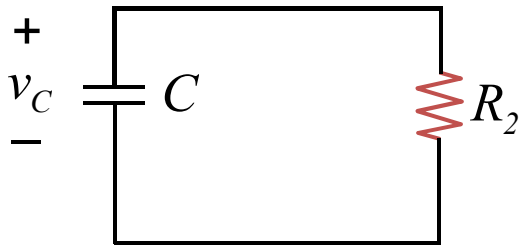


T_2 : S_2 closed, S_1 open





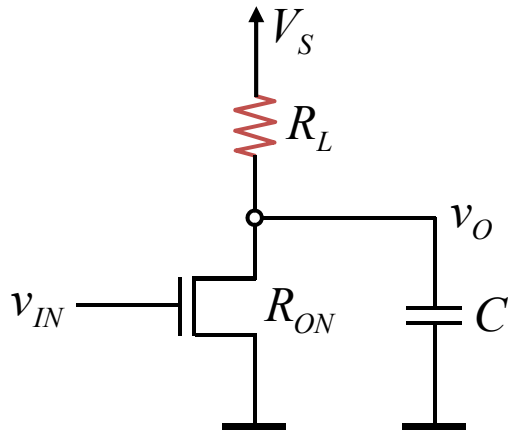
T_2 : S_2 closed, S_1 open



Putting the two together

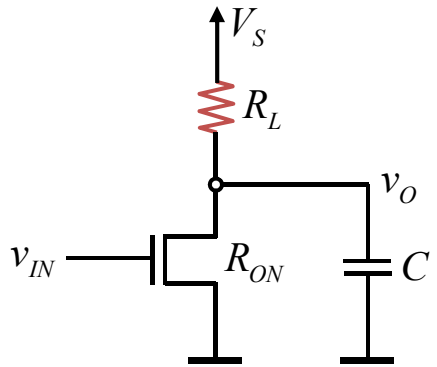
Back to our inverter —

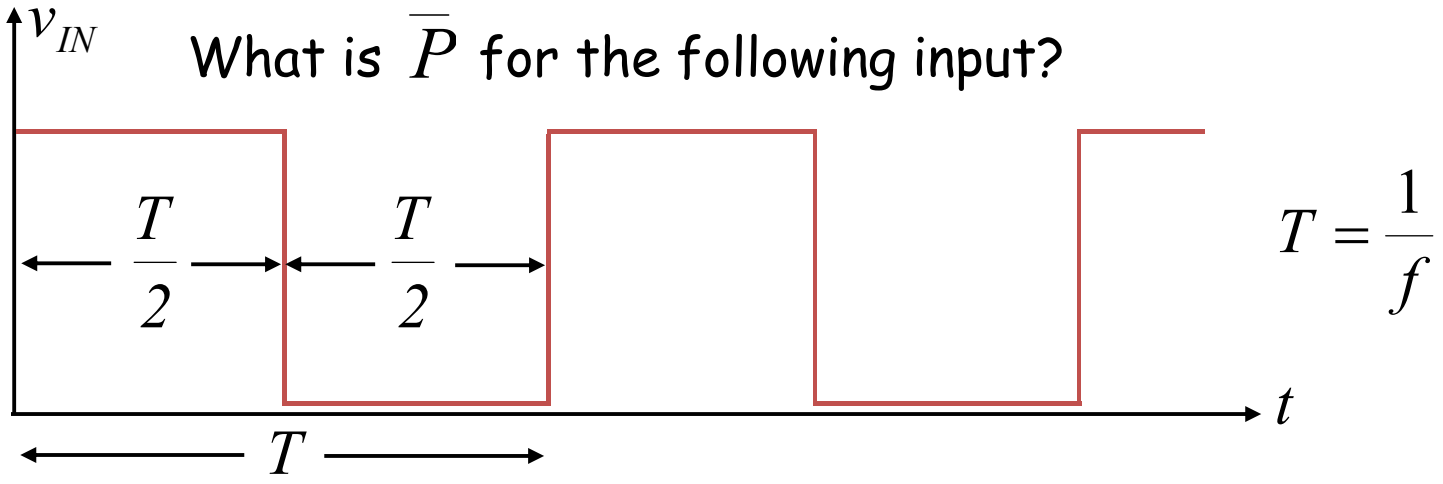
What is $\overline{P}$ for the following input?





Equivalent Circuit





$$T = \frac{1}{f}$$

What is $\overline{P}$ for gate?

What is $\overline{P}$ for gate?

Total power for a gate: $\overline{P} = \frac{V_S^{\,2}}{2R_L} + CV_S^{\,2} f$ when $R_L >> R_{ON}$

$\overline{P}_{STATIC}$ $\overline{P}_{DYNAMIC}$

Question: what does our previous style of building logic gates have to do with the sun?



Some startling numbers…

One gate: $\overline{P} = \frac{V_S^{\,2}}{2R_L} + CV_S^{\,2} f$

$C = 1f\,F$

$R_L = 10\,k\Omega$

$f = 100 \times 10^6$

$V_S = 5V$

Question: what does our previous style of building logic gates have to do with the sun?



