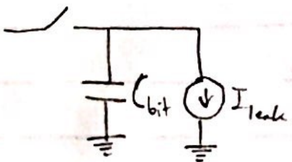
Homework #8

#2 DRAM

a)



$C_{bit} = 18\,fF \; (1\,fF = 10^{-15} F)$

$V_{init} = 1.2V$ (must be ≥ 0.8V to retain value of 1)

$V_{min} = 0.8V$

$Q = CV$

$Q_{bit} = C_{bit} V_{bit}$ ← differentiate

$I_{leak} = \frac{dV_{bit}}{dt} C_{bit}$

$I_{leak} = \frac{0.4V}{0.001s}(18 \times 10^{-15} F)$

$= \boxed{7.2\,pA}$

b) $C = \varepsilon \frac{A}{d}$

$= \varepsilon \frac{1024 \times (0.5 \times 10^{-6} m)(0.5 \times 10^{-6} m)}{0.1 \times 10^{-6} m}$

$= \boxed{22.65 \times 10^{-15} F}$

c) $Q_{bit} = C_{bit} V_{bit}$ (initially)

$\underbrace{C_{bit} V_{bit}} = \underbrace{(C_{bit} + C_{wire}) V_{column}}_{\text{(final)}}$

$\frac{18}{38} V_{bit} = V_{column}$

$\boxed{\text{so} \Rightarrow \begin{array}{l} 0.568V \text{ if initial is } 1.2V \\ 0V \text{ if initial is } 0V \end{array}}$

d) Rearranging formula from (c)

$V_{column} = \frac{C_{bit} V_{bit}}{C_{bit} + C_{wire}}$

$0.4V = \frac{(18fF)(1.2V)}{18fF + C_{max}}$

$C_{max} = 36\,fF$

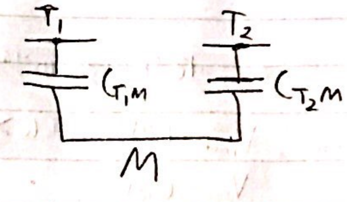
Using part (b)

$36 \times 10^{-15} fF = \varepsilon \frac{x (0.5 \times 10^{-6} m)^2}{0.1 \times 10^{-6} m}$

$\boxed{x = 1626}$

#13) Mag-lev Train

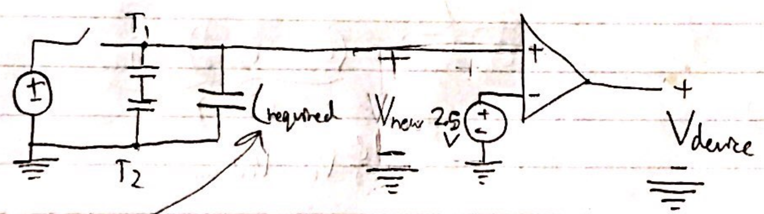
a) $$\boxed{C_{T_1M} = C_{T_2M} = \varepsilon \frac{WL_{Train}}{h}}$$

b) 

c) We want C_{eff}. They're in series → $\frac{1}{C_{eff}} = \frac{1}{C_{T_1M}} + \frac{1}{C_{T_2M}}$

$$\boxed{C_{eff} = \frac{\varepsilon WL_{Train}}{2h}}$$

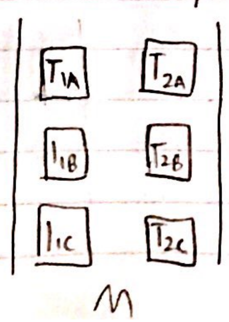
d) C_{eff} is inversely related to distance between train & track.



$$C_{required} = 8.85 \times \frac{100 \cdot 0.01}{200^{-2}} = \boxed{442.5\,pF}$$

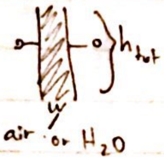
V_{new} measures the voltage.

e) Break the strips up into blocks.



#4) It's Finally Raining

a)



$$C_{empty} = \frac{\varepsilon_{air} h_{tot} w}{w} = \boxed{\varepsilon h_{tot}}$$

$$C_{full} = \frac{\varepsilon_{H_2O} h_{tot} w}{w} = \boxed{81 \varepsilon h_{tot}}$$

b) $$C_{H_2O} = \frac{\varepsilon_{H_2O} h_{H_2O} w}{w} = 81 \varepsilon h_{H_2O} \qquad C_{air} = \frac{\varepsilon_{air}(h_{tot} - h_{H_2O}) w}{w} = \varepsilon(h_{tot} - h_{H_2O})$$

Since the 2 capacitors are ||, we just add them.

$$\boxed{C_{tank} = \varepsilon(h_{tot} + 80 h_{H_2O})}$$

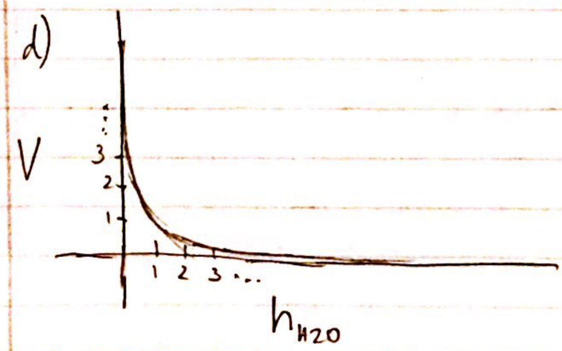
c) ϕ_1) $$Q_{C_{tank}} = Q_{C_{known}} = C_{eff} V_{in} = \underbrace{\left(\frac{C_{tank} C_{known}}{C_{tank} + C_{known}}\right)}_{} V_{in}$$

ϕ_2) charge share

$$2\left(\quad\right) = V_{out} \underbrace{(C_{tank} + C_{known})}_{\text{in } \phi_2\text{, they are 'in parallel'}}$$

$$\boxed{V_{out} = 2V_{in}\left(\frac{C_{tank} C_{known}}{(C_{tank} + C_{known})^2}\right)}$$

d)



e) $$\left(\frac{1}{C_{tank}} + \frac{1}{C_{known}}\right)(C_{tank} + C_{known}) = \frac{2V_{source}}{V_o}$$

$$\frac{C_{tank}}{C_{known}} + \frac{C_{known}}{C_{tank}} = 2\left(\frac{V_{in}}{V_o} - 1\right)$$

quadratic formula w/ $\frac{C_{tank}}{C_{known}} = x$

$$\boxed{h_{water} = \frac{h_{tot}}{80}\left(\frac{V_{source}}{V_o} - 2 + \sqrt{\left(\frac{V_{source}}{V_o} - 1\right)^2 - 1}\right)}$$

f) $[V_o] = V$ ✓ $[h_{H_2O}] = m$ ✓

#5)

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We worked together on the entire homework.