(astore 9 (numV 13))
8 (numV 12)
9 (numV 10))

memory ⇒ global ⇒ finite/fixed
⇒ linear

Finite memory
⇒ re-use old memory

What can be re-used?
- if don't use it in the future ⇒ free it
- duplicated data (!) ← hash consing
- could re-calculate ← cache

free(p) ⇒ don't need it ⇒ humans just know
int*f() 3
int*p = malloc(Y);
return p;

intuition = "you can't get to it"

soundness don't free early
⇒ completeness don't free late

int*p = malloc;
if (f(x) == 0)
sp = ...
⇒ f = "return 0 if x as a T. M. halts"

lest; not mention p;....
malloc
\[ \text{ideal: } O(1) \]
\[
\downarrow
\]
\[
\text{return } [\text{free}_n + \text{size}]
\]
\[
\begin{array}{c}
A \\
B \\
C \\
D
\end{array}
\]
\[
\text{free}(B)
\]
\[
O(\lg m) \quad (\text{some } O(1gn))
\]
\[
\begin{array}{c}
A \\
B
\end{array}
\]
\[
\text{free}(C)
\]
\[
\text{malloc + free}
\]
\[
\text{tree: } O(1)
\]

\[
\text{mark pointers}
\]
\[
\text{reference counting}
\]
\[
\text{up}(p) \quad \text{if}(p\rightarrow\text{count} = \text{MAX}) \quad \text{down}(p) \quad \text{if}(\text{MAX} \text{ do nothing})
\]
\[
p = p\rightarrow\text{count} + 1
\]
\[
\text{if}(~p\rightarrow\text{count} = 0)
\]
\[
\text{free}(p)
\]
\[
\text{posn} \cdot m = f(\ldots)
\]
\[
\text{m} = \text{up}(m)
\]
\[
g(m) \\
\rightarrow \text{C}
\]
\[
\text{m} = \text{down}(m)
\]
\[
\text{global} = m
\]
\[
global = \text{up}(1)
\]

malloc: same \(O(\lg n)\) 

soundness: trusts humans

free: same \(O(\lg n)\) 

how completeness:

mem: \((1 + \text{size} + \text{count})\) use: \(O(\text{references})\)

\[
\text{cyclic structures are never freed}
\]