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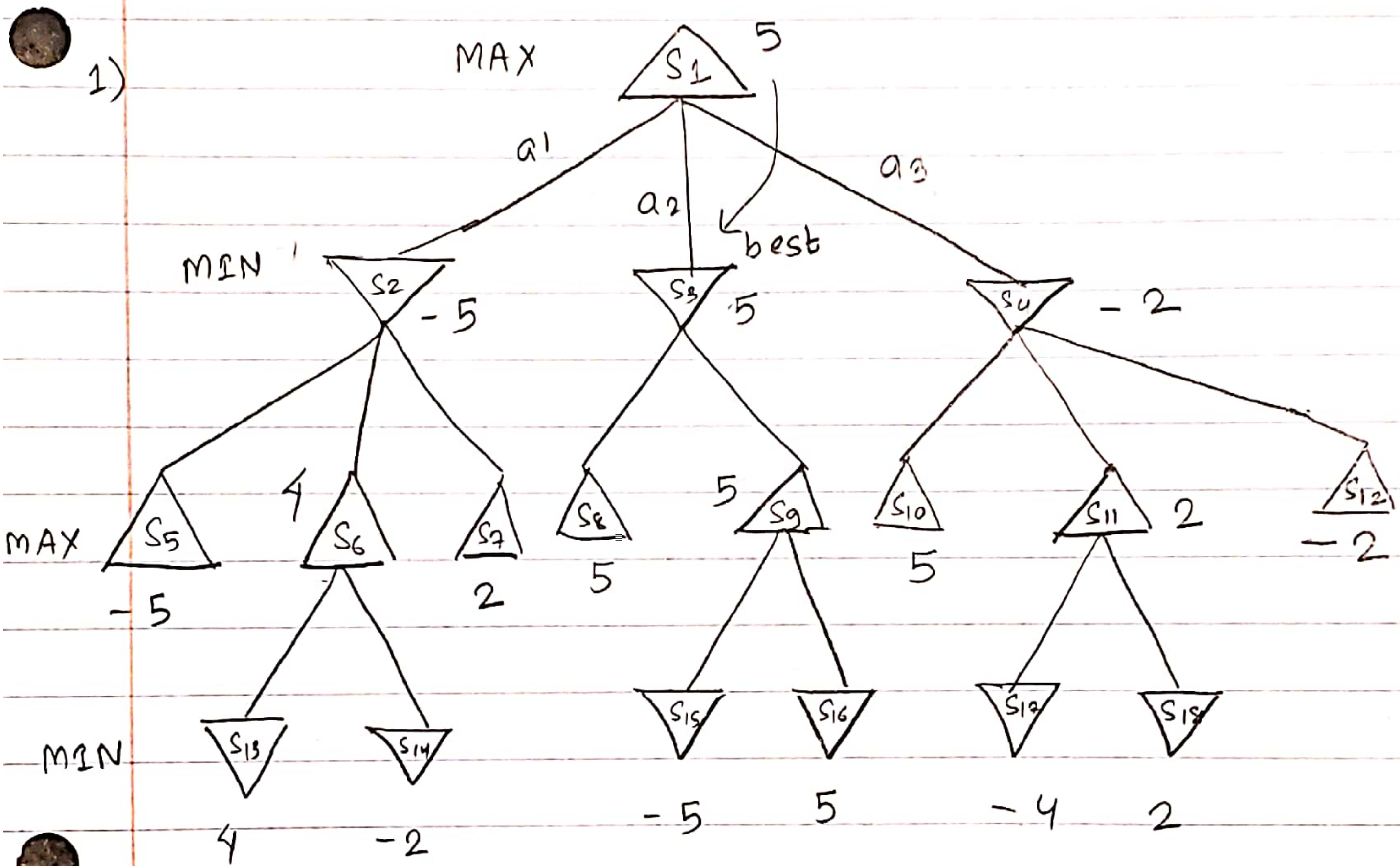
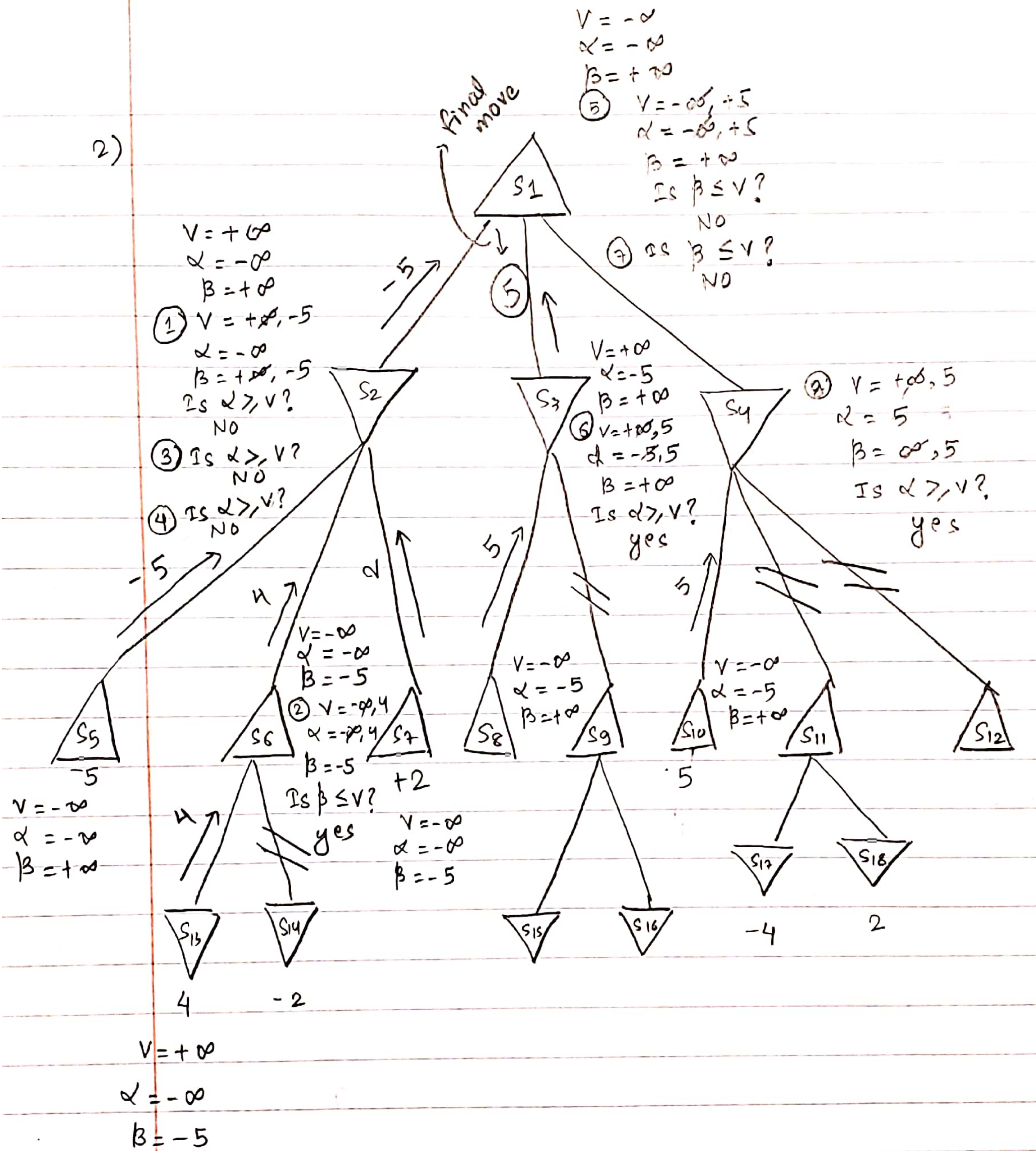
1)



↳ Values in each nodes are shown in the diagram above.

↳ MinMax will select a_2 to be the best move, since it's utility value = 5

2)



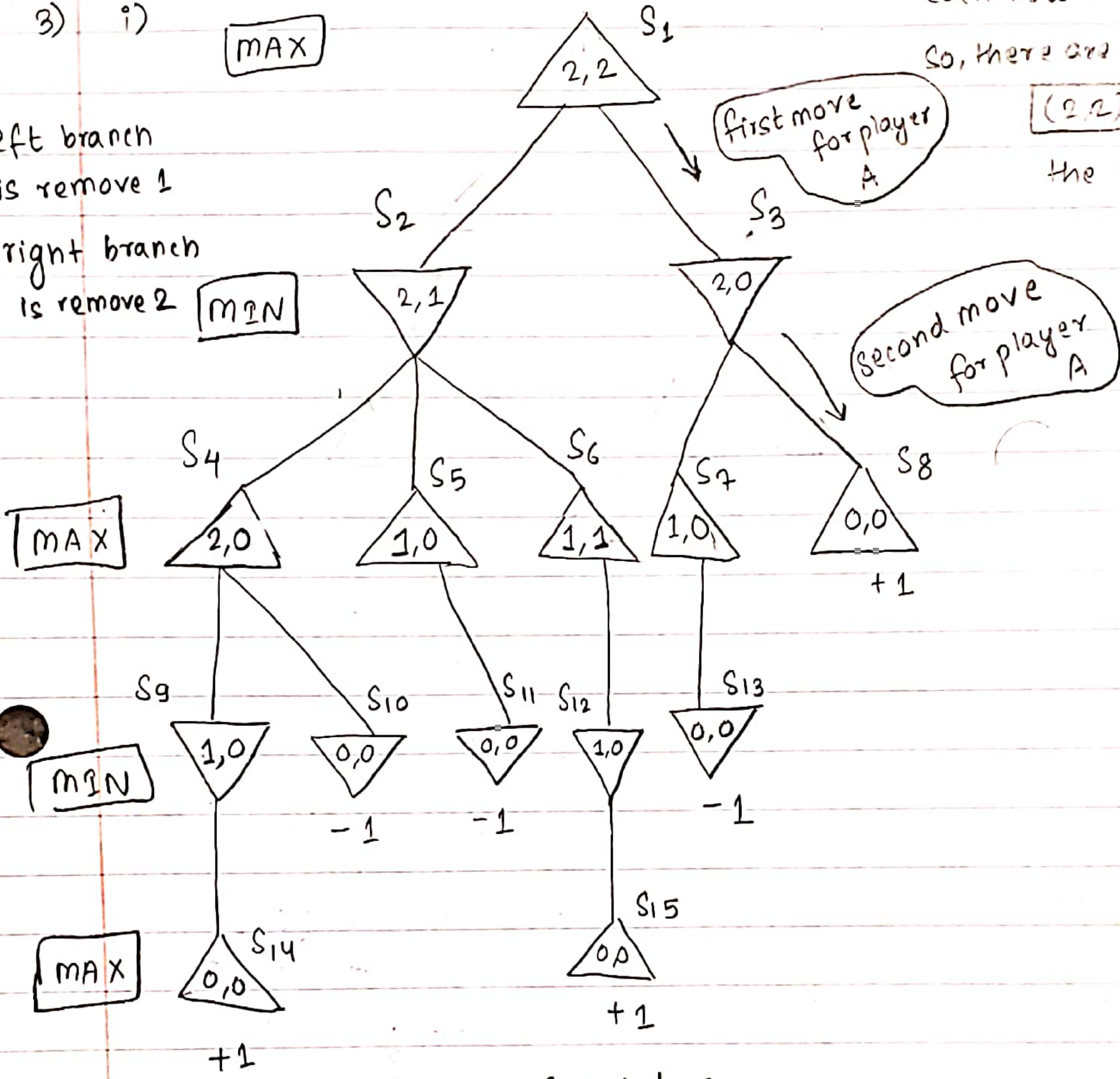
Here, Pruned branches are marked as $\boxed{=}$.

There are two bowls and each bowl has two stones. So, there are a total of $\boxed{(2,2)}$ 4 stones in the beginning

3) i)

↳ left branch is remove 1

↳ right branch is remove 2

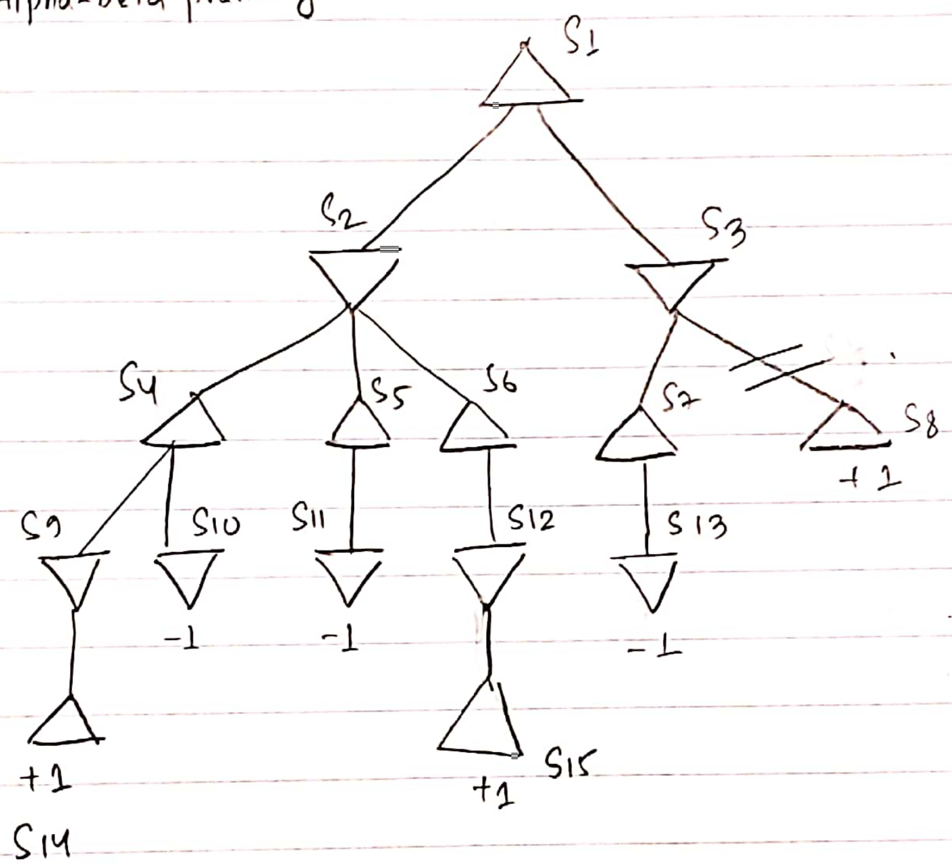


Minmax Search tree

ii) Utility values for terminal nodes are shown in the tree. The minmax values are also computed for each node

iii) An optimal strategy for player A to win will be $\boxed{S_1 \rightarrow S_3 \rightarrow S_8}$ as shown in the diagram.

iv) Alpha-beta pruning



↳ pruned branch is indicated by [=] in the diagram

↳ It will give the same value as MINMAX algo but will optimize the algorithm.

4) Converting KB into CNF

KB: $((P \vee U) \Rightarrow (S \wedge R)) \wedge (Q \Leftrightarrow P) \wedge Q \wedge (R \Leftrightarrow T)$

Here, Removing $\Leftrightarrow$

$((P \vee U) \Rightarrow (S \wedge R)) \wedge (Q \Rightarrow P) \wedge (P \Rightarrow Q) \wedge Q \wedge (R \Rightarrow T) \wedge (T \Rightarrow R)$

Now, Removing $\Rightarrow$

$((\neg(P \vee U)) \vee (S \wedge R)) \wedge (\neg Q \vee P) \wedge (\neg P \vee Q) \wedge Q \wedge (\neg R \vee T) \wedge (\neg T \vee R)$

Moving $\neg$ inwards (using demorgans' law):

$((\neg P \wedge \neg U) \vee (S \wedge R)) \wedge (\neg Q \vee P) \wedge (\neg P \vee Q) \wedge Q \wedge (\neg R \vee T) \wedge (\neg T \vee R)$

Using Distributive property:

$((\neg P \wedge \neg U) \vee S) \wedge ((\neg P \wedge \neg U) \vee R) \wedge (\neg Q \vee P) \wedge (\neg P \vee Q) \wedge Q \wedge (\neg R \vee T)$
$\wedge (\neg T \vee R)$

The above form is in CNF.

Now, α : $(S \wedge T)$

Negation of α : $\neg(S \wedge T)$

Using Demorgan's law : $(\neg S \vee \neg T)$

Checking if KB entails α using recursion:

$\Rightarrow$

$(\neg P \lor S) \land (\neg U \lor S) \land (\neg P \lor R) \land (\neg U \lor R) \land (\neg Q \lor P)$
$(\neg P \lor Q) \land Q \land (\neg R \lor T) \land (\neg T \lor R) \land (\neg S \lor \neg T)$

$$\underbrace{(\neg S \lor \neg T) \quad (\neg R \lor T)}_{\neg S \lor \neg R}$$

$$\underbrace{(\neg S \lor \neg R) \quad (S \lor \neg P)}_{\neg R \lor \neg P}$$

$$\underbrace{(\neg R \lor \neg P) \quad (R \lor \neg P)}_{\neg P}$$

$$\underbrace{\neg P \quad (\neg Q \lor P)}_{\neg Q}$$

$$\underbrace{\neg Q \quad Q}_{\phi}$$

Empty clause.

Thus,

KB entails α using resolution.

proved //

i) Done in Canvas

ii) Expanding Knowledge base:

$S\_T \wedge F\_T \Rightarrow S\_T\_T$

$S\_T \wedge F\_R \Rightarrow S\_T\_R$

$S\_T \wedge F\_H \Rightarrow S\_T\_H$

$S\_R \wedge F\_R \Rightarrow S\_R\_R$

$S\_R \wedge F\_T \Rightarrow S\_R\_T$

$S\_R \wedge F\_H \Rightarrow S\_R\_H$

$S\_H \wedge F\_H \Rightarrow S\_H\_H$

$S\_H \wedge F\_T \Rightarrow S\_H\_T$

$S\_H \wedge F\_R \Rightarrow S\_H\_R$

iii) Forward Chaining:

Given: $\forall x \forall y\, [short(x) \wedge Fast(y) \Rightarrow stronger(x,y)]$

Now, for stronger (Tom, Richard):

$\forall x \forall y\, [Short(Tom) \wedge Fast(Richard) \Rightarrow Stronger(Tom, Richard$

i.e. $S\_T \wedge F\_R \Rightarrow S\_T\_R$

we need to shat KB entails S_T_R using forward chaining.

1. S_T
2. F_R
3. S_T, F_R $S\_T \wedge F\_R \Rightarrow S\_T\_R$ [using modus-ponens on (1) & (2)]

Using Forward chaining, we proved that the knowledgebase entails Stronger (Tom, Richard).

Hence, proved //