

MAE 301 Final Project

An Analysis on the Game of Basketball

Tajinder Uppal, Arun Yadav, Brian Mendonca

Also note: We all did the same amount of work on the project and we all want to receive the same grade

EXECUTIVE SUMMARY

The team began by postulating a number of questions such as: Are particular races better at shooting? Or, are particular courts at the SDFC (Sun Devil Fitness Complex) better at shooting? Or, how has the pro level NBA game affected the amateur level game?

To answer these questions, each member of the team routinely visited the SDFC to observe basketball games. Data was collected by recording each observed shot onto a shot chart. This shot chart accounted for: where the shot was taken from, the race of the shot-taker, which court the shot was taken on, and which team won the game. A total of 31 basketball games were recorded, played to 15 points.

This data was then organized and analyzed by conducting a variety of hypothesis tests. Here are the team's conclusions:

Null Hypothesis	Conclusion
All races shoot the same overall percentage	Cannot reject
All courts shoot the same overall percentage	Rejected
Each race takes the same proportion of shots from 3	Rejected
All races shoot the same overall <i>effective</i> percentage	Cannot reject
All courts take the same proportion of shots from each area	Cannot reject
Winning and losing teams shoot the same proportion of 3-point shots	Cannot reject
Winning and losing teams shoot the same 3-point percentage	Rejected

Additionally, it can be concluded that the pro level NBA game has dramatically impacted the amateur level game. The observations at the SDFC align with recent NBA trends: the game of basketball has become a “3-point game”, with *almost all* shots coming from beyond the 3-point line or within the paint, and almost no shots from midrange.

INTRODUCTION

Problem Statements

- What factors contribute to the making of a shot?
- What factors contribute to the winning of a game?
- How has the pro level NBA game affected amateur basketball?

Hypotheses and Research Questions being investigated

- Do particular races shoot better percentages?
- Do particular courts at the SDFC shoot better percentages?
- Do winning teams shoot more 3 pointers?
- Do winning teams make more 3 pointers?
- Do different races have different playing styles?
- Do different courts have different playing styles?

Background Information

The team plays a lot of basketball at the SDFC. From our time there, we have observed that players often stratify themselves based off skill. The best players tend to play on 3-Bay court, and the worst players tend to play on 2-Bay court. This led us to ask the question: Do certain courts shoot better percentages?

Additionally, we have noticed that the African-American players at the SDFC tend to be much better basketball players. This led us to ask the question: Do particular races shoot better percentages?

Likewise, we asked the question: What factors contribute to the winning of a game? Here we focused on the influence and power of the 3-point shot, which we have often observed to determine the fate of a game all on its own. This is due to the fact that when playing pickup basketball at the SDFC, standard 3-point shots actually count as 2 points, whereas standard 2-point shots only count as 1 point. Thus, the reward of making a 3-pointer is twice that of a 2-pointer.

In recent years, the NBA has witnessed a drastic change in playing style. The new game of basketball is often characterized as the “3-Point game”, where the proportion of shots taken from 3-point range has increased, and the proportion of shots from midrange has decreased.¹ Given this NBA trend, the team wanted to see if a trickle-down effect could be observed at the amateur level.

PROCEDURE

Data Collection

- Each shot taken over the course of the game was recorded using the [shot chart](#) and the following convention:
 - Each shot was distinguished by a letter for the shot taker's race, and a corresponding plus or minus indicating a make or miss (W- White, A- Asian, B- Black, H- Hispanic)
 - Each shot also had a corresponding location on the shot chart for the purpose of grouping into Paint, Midrange, and 3-Point shots

Data Organization

- After recording each game, the data was recorded in the [spreadsheet](#), where shots are categorized by race, court, and the area from which the shot was taken from (paint, midrange, 3-point)
- Data was also categorized by winning and losing teams, to determine the factors that led to teams winning games

Hypothesis Testing

- To answer the questions proposed, the team utilized a number of hypothesis tests, sometimes using the built in Excel function T.TEST
- When the T.TEST function did not work (usually due to uneven data set sizes) the T-tests were done manually, by finding the degrees of freedom and t-score using the following formulas. For the t-score calculation, $(\mu_1 - \mu_2)$ is assumed to be 0, meaning the population mean proportions do not differ. Additionally, all analysis was done under the assumption that σ_1^2 is not equal to σ_2^2 , meaning the variables are heteroscedastic.

$$Degrees\ of\ Freedom = \frac{\left(\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2} \right)^2}{\frac{\left(\frac{S_1^2}{n_1} \right)^2}{n_1 - 1} + \frac{\left(\frac{S_2^2}{n_2} \right)^2}{n_2 - 1}}$$

$$T - Score = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

RESULTS

Question 1: Do particular races shoot better percentages?

Null: Blacks and whites shoot the same percentage.

Alternate: Blacks and whites do NOT shoot the same percentage. (Two-tail)

Overview:

Upon compiling the data for the 31 games recorded, the group listed 603 attempts for B (Black), 446 attempts for W (White), 182 attempts for A (Asian), and 118 attempts for H (Hispanic). Due to a lack of data for the A (Asian) and H (Hispanic) races, we chose to exclude these races in our analysis, and focused solely on distinctions in shot percentage between the B (Black) and W (White) races. The overall shooting percentages are provided in Figure 1 below:

	PAINT		MIDRANGE		3 POINT		TOTAL	
	Makes	Attempts	Makes	Attempts	Makes	Attempts	Makes	Attempts
(B) Black	147	243	16	50	97	310	260	603
%		60.49382716		32.000000		31.29032258		43.11774461
(W) White	115	193	17	59	60	194	191	446
%		59.5854923		28.81355932		30.92783505		42.82511211

Figure 1

Analysis:

It was reported that both races shoot similar percentages. Next, a 2-sample proportion T-test was executed, using the built-in excel function, to determine whether the difference between the mean proportions for paint, midrange, 3-point, and overall, were statistically significant.

T.TEST (Sample1, Sample2, 2, 3)

Where

- Sample1 is the set of shooting percentages for blacks each game,
- Sample2 is the set of shooting percentages for whites each game,
- 2 indicates a two-tailed test
- 3 indicates an unequal variance was assumed (heteroscedastic)

Shot Vicinity	p-value
Paint	0.864526004
Midrange	0.9467036715
3-Point	0.4178742658
Overall	0.4123185697

With $\alpha = 0.05$ and a two-tailed test, the group obtained the above p-values. Based on the data, blacks and whites did not shoot statistically significant, different percentages from paint, midrange, 3-point, or overall. Therefore, the conclusion of this test was to **accept the null**, as we do NOT have sufficient evidence to say that blacks and whites shoot different percentages.

Question 2: Do particular courts at the Sun Devil Fitness Center shoot better percentages?

Null: The players at 3-Bay court and 2-Bay court shoot the same percentages.

Alternate: The players at 3-Bay court shoot better than those playing at 2-Bay. (One-tail)

Overview:

The basketball players at the Sun Devil Fitness Center tend to organize their competition according to the court. In general, the higher skilled players play on the 3-Bay courts, while the lower skilled play on the 2-Bay courts downstairs. These trends are easily noticeable for frequent visitors to the SDFC, and so the group was interested to see if there was a statistically significant difference in the shot percentages of games played in the 3-Bay court and those in 2-Bay. Moreover, since we know the 3-Bay courts have better players than those in 2-Bay, we chose a one-tailed test. The shot percentages were grouped according to the court, and the totals are displayed in Figure 2 below. Also shown is the breakdown of shot vicinity, indicating where the player shot the ball from-- paint, midrange, or 3-point. For simplicity, analysis was only done on the overall shot percentages.

	PAINT		MIDRANGE		3 POINT		TOTAL	
	Makes	Attempts	Makes	Attempts	Makes	Attempts	Makes	Attempts
2 Bay	129	239	16	58	80	278	225	575
%		53.9748954		27.5862069		28.77697842		39.13043478
3 Bay	210	324	21	74	121	376	352	774
%		64.81481481		28.37837838		32.18085106		45.47803618

Figure 2

Analysis:

There was a clear distinction in shot percentage in the paint, while 3-point and midrange percentages were more similar. In total, the 2Bay courts shot at 39.13% while 3Bay shot at 45.48%. The group conducted a 2-sample T-test for a difference in mean proportions. However, this time the two sets of data were of unequal size, barring us from utilizing the T.TEST function on excel. And so, we manually found the Standard Deviation values, Degrees of Freedom, T-Scores, and corresponding p-values. For the total shot percentages, we derived the following values provided in Figure 3.

TOTALS	
2bay total SD	9.950138
3bay total SD	7.688144
DOF	21.72780484
T-Score	-1.922673
p-value	0.311816234

Figure 3

Conducting a one-sided test with $\alpha = 0.05$ results in a p-value of **0.0338637**, which indicates there was significant evidence to reject the null hypothesis and accept the alternative hypothesis. Players at 3-Bay **do** shoot better percentages than players at 2-Bay.

Question 3: Do winning teams attempt more 3-Pointers? Do winning teams make more 3-pointers?

Overview:

This question requires two sets of hypotheses. The first set has to do with proportion: did winning teams take more of their total shots from 3? The second set simply has to do with 3-point percentage.

Null: The winning team and the losing team take the same proportion of 3-point shots.

Alternate: The winning team takes a higher proportion of 3-point shots. (One-tail)

Null: The winning team and the losing team have the same 3-Point percentage.

Alternate: The winning team has a higher three 3-Point percentage. (One-tail)

Winning team: Average Proportion of 3-point shots		0.4950903107
Losing team: Average Proportion of 3-point shots		0.4903655609
Winning team: Average 3-point percentage		36.88567599
Losing team: Average 3-point percentage		25.77385428

Figure 4

Analysis:

It was observed that each team shot a similar proportion of their shots from 3. However, the average 3-Point percentage did differ between teams. To further analyze the data, a T-Test for a difference in means was conducted for both sets of data.

3-point Percentage p-value	3-point Proportion p-value
0.002770291467	0.4445987239

Figure 5

The reported p-value for 3-point **percentage** was 0.00277. Thus, the null hypothesis can be rejected and the alternate hypothesis can be accepted. Winning teams shoot a better percentage from 3.

The reported p-value for 3-point **proportion** was 0.444. Thus, the null hypothesis can NOT be rejected.

From this analysis, we were not able to prove that taking a higher proportion of a team's shots from 3 increases the team's likelihood of winning. On average, winning teams took 49.509% of their shots from 3, whereas losing teams took 49.03% of their shots from 3. Thus, it appears 3-point proportion is not a significant factor in determining the outcome of the game. A team cannot simply take a higher proportion of 3's and hope to win.

It **can** be said that 3-point percentage plays a *vital* role in determining the outcome of the game.

- Winning teams shot 36.88% from 3, whereas losing teams shot only 25.77%
- In 23/31 games recorded, the winning team shot a higher 3-point percentage
- Winning teams made on average 3.968 three pointers, whereas losing teams only made 2.516

Question 4: Do different races have different playing styles?

Overview:

To answer this question, the team only looked at the proportion of shots blacks and whites took from each vicinity. This is not the only measure of playing style, but it is the only measure being investigated.

Null: All races take the same proportion of their shots from 3.

Alternate: All races do NOT take the same proportion of their shots from 3. (Two-tail)

Percentage of shots taken from each vicinity by Race		
	Black	White
P Proportion	41.56521739	43.2735426
M Proportion	8.291873964	13.22869955
3 Proportion	51.40961857	43.49775785

Figure 6

Analysis:

It can be seen that the greatest deviation is in the average 3-Point proportion between the two races. To analyze if this deviation is statistically significant, a two-tailed T-Test was conducted.

The T-Test output a p-value of 0.03296, therefore providing enough evidence to REJECT the null hypothesis and accept the alternate hypothesis. Black players do shoot a higher proportion of 3's than white players.

Question 5: Do different races have different effective field goal percentages?

Overview:

Upon completion of shot percentage and shot proportion data, the group found blacks and whites shoot at about the same percentage, yet their proportion of three pointers taken was considerably different. Blacks took a much higher proportion of threes out of all their total shots. Because of this distinction, a new question arose. If both races shoot at the same percentage, but one takes a higher proportion of three pointers, would this mean that one group is more efficient on the basketball court? This opens the discussion to an essential basketball statistic-- effective field goal percentage. Simply put, this percentage considers the fact that a three pointer counts twice as much as a two pointer in pickup games. The formula is:

$$eFG \% = \frac{(2pt\ Made) + 2 * (3pt\ Made)}{Total\ Attempts} \times 100$$

Another possible confusion must be addressed. In normal basketball, a standard 2-point shot counts for 2 points. Likewise, a standard 3-point shot counts for 3 points. *However*, in pickup basketball at the SDFC, a standard 3-point shot counts as 2 points, and a standard 2-point shot counts as 1 point.

Our statistical musing led to the following hypothesis test:

Null: All races shoot at the same *effective* field goal percentage.

Alternate: Blacks shoot at a higher *effective* field goal percentage than whites. (One-tail)

The averages, standard deviation, and degrees of freedom were calculated for the effective field goal percentages for blacks and whites, resulting in the following percentages shown in Figure 8:

	Black	White
eFG %	59.2040%	56.27083 %

Figure 8

Analysis:

The results show a minimal difference between the overall effective field goal percentage of blacks and whites, differing by just under three percent. A 2-sample T test was conducted to test a difference in mean proportion, displayed in Figure 9 below:

eFG between B (Black) and W (White)		
DOF	56.99931762	
T-Score	0.4933904137	
P Value	0.311816234	

Figure 9

Using a one-sided test with $\alpha = 0.05$, the p-value found is **0.311816**, indicating that there is NOT enough evidence to reject the null hypothesis. However, the group likened this conclusion to a lack of data, believing that a larger sample size for both races could likely show a significant difference in effective field goal percentage. With the current data set though, the conclusion of this test is to **accept the null**, as we have INSUFFICIENT evidence to conclude that the effective field goal percentage differs among blacks and whites playing at the SDFC.

Question 6: Do different courts have different playing styles?

Null: All courts take the same proportion of shots from each vicinity.

Alternate: All courts do NOT take the same proportion of shots from each vicinity.

Again, the proportion of shots taken from each vicinity is not the only measure of playing style, but it is the only measure being investigated.

Proportion of shots taken from each vicinity between courts			
	2Bay	3Bay	
P Proportion	41.56521739	41.86046512	
M Proportion	10.08695652	9.560723514	
3 Proportion	48.34782609	48.57881137	

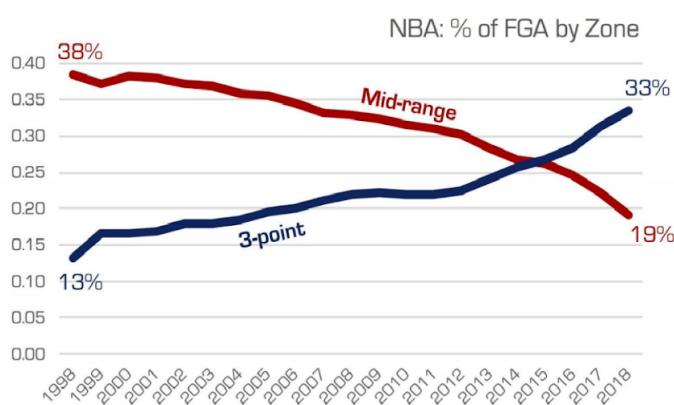
Figure 10

As seen from the table above, both courts, despite their disparity in skill level, still have very similar playing styles, and shoot almost the exact same proportion of shots from each vicinity. The team never did a T-Test on this part of the analysis. However, it can be clearly seen from the similarity between proportions that there is INSUFFICIENT evidence to reject the null. Thus, we conclude that the proportion of shots taken from each vicinity does not differ among the two courts discussed.

Question 7: How has pro level NBA basketball affected amateur basketball?

Overall Proportion of shots taken from each vicinity at SDFC			
P Proportion	41.73461824		
M Proportion	9.785025945		
3 Proportion	48.48035582		

Figure 11



NBA: Field Goal Percentage by Zone

Vicinity	1998	2018
Paint	49 %	48 %
Midrange	38 %	19 %
3-Pointers	13 %	33 %

Figure 12-13: Graph and Data obtained from ShotTracker₁

Given that the playing style of the NBA has changed to encompass many more 3-pointers and many fewer mid-rangers, can a trickle-down effect of this shift in playing style be witnessed at our local SDFC? Upon compiling all data and organizing it according to shot vicinity, it is clear that the pro-level play has had a profound impact on basketball at all levels. The shot proportion is highest for the 3-pointer, with nearly half of all shots being taken from behind the three point line. Moreover, the midrange shot has seen a steady decline in popularity, with mid-range shots making up less than 10 percent of the total. Both of these trends stem from the shift in playing style of professional basketball, and its effects have clearly trickled down into all levels of competitive play.

CONCLUSIONS

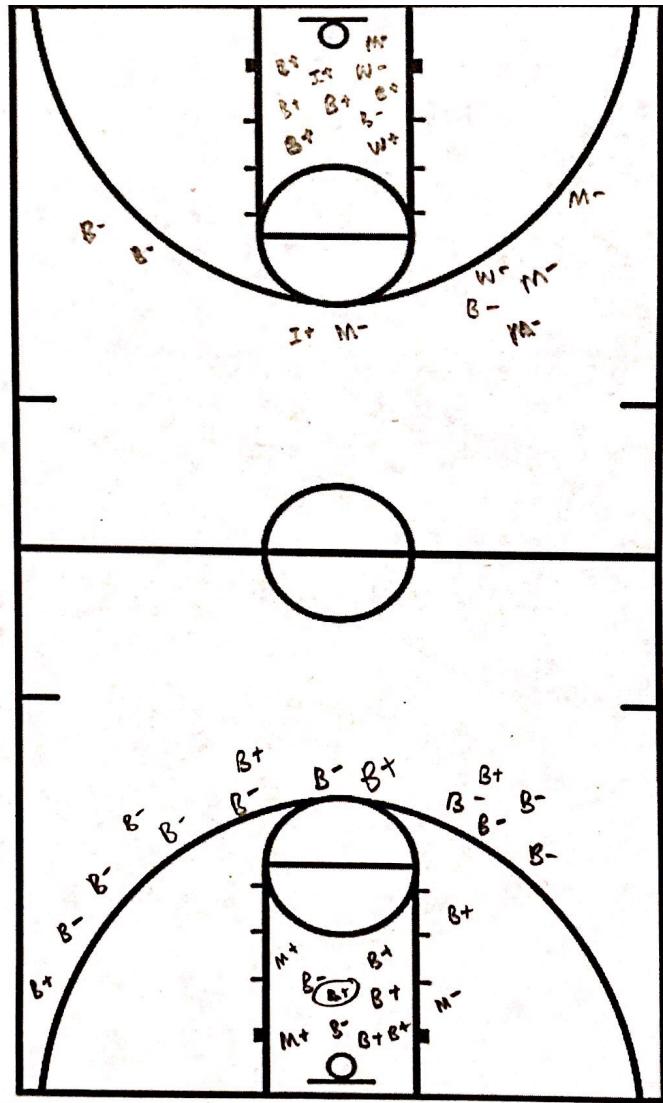
Upon completion of all data analysis, the group was able to draw several key statistical conclusions:

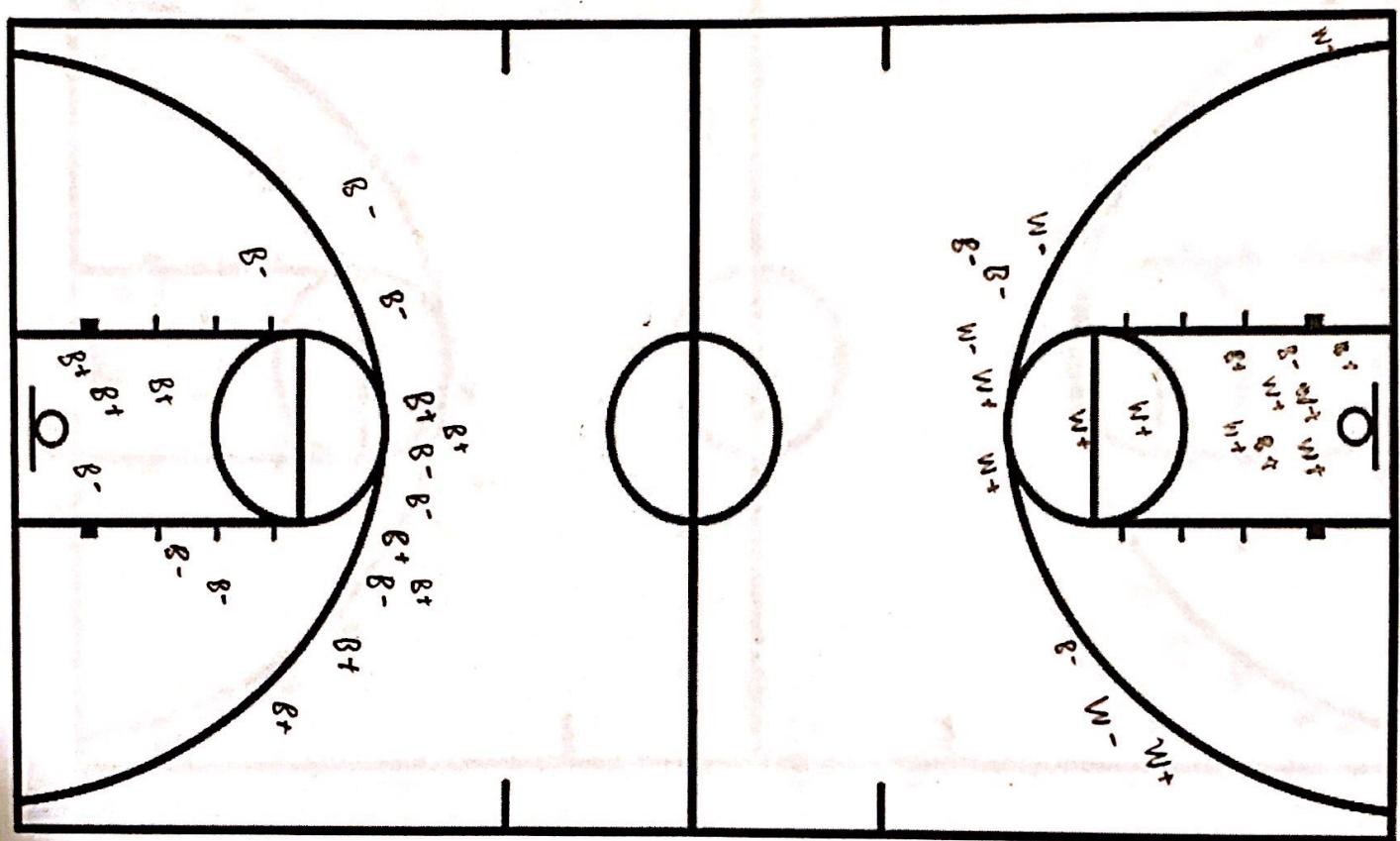
- Shooting percentage does **not** differ among races playing at the SDFC
- Players at 3-Bay court shoot **better** percentages than players at 2-Bay court
- The playing style of teams playing at the 3-Bay court and 2-Bay court does **not** significantly differ. Both courts take a very similar proportion of shots from each vicinity.
- The proportion of a team's shots from 3-point range does **not** significantly differ between the winning and losing team.
- Making 3-pointers is **vital** in determining the outcome of a game. On average, winning teams shoot 11.11% better from 3 and make 1.452 more 3-pointers.
- Black and white players **do** have different playing styles. The proportion of shots taken from 3-point range is significantly **higher** for blacks than it is for whites.
- The effective field goal percentage does **not** differ among blacks and whites. However, with more data, we may be able to conclude that black players shoot a higher effective field goal percentage.
- A trickle-down effect from the NBA to the amateur level can be observed. Paint shots and 3-point shots dominate the proportion of shots taken, whereas mid-range shots have all but ceased to exist.

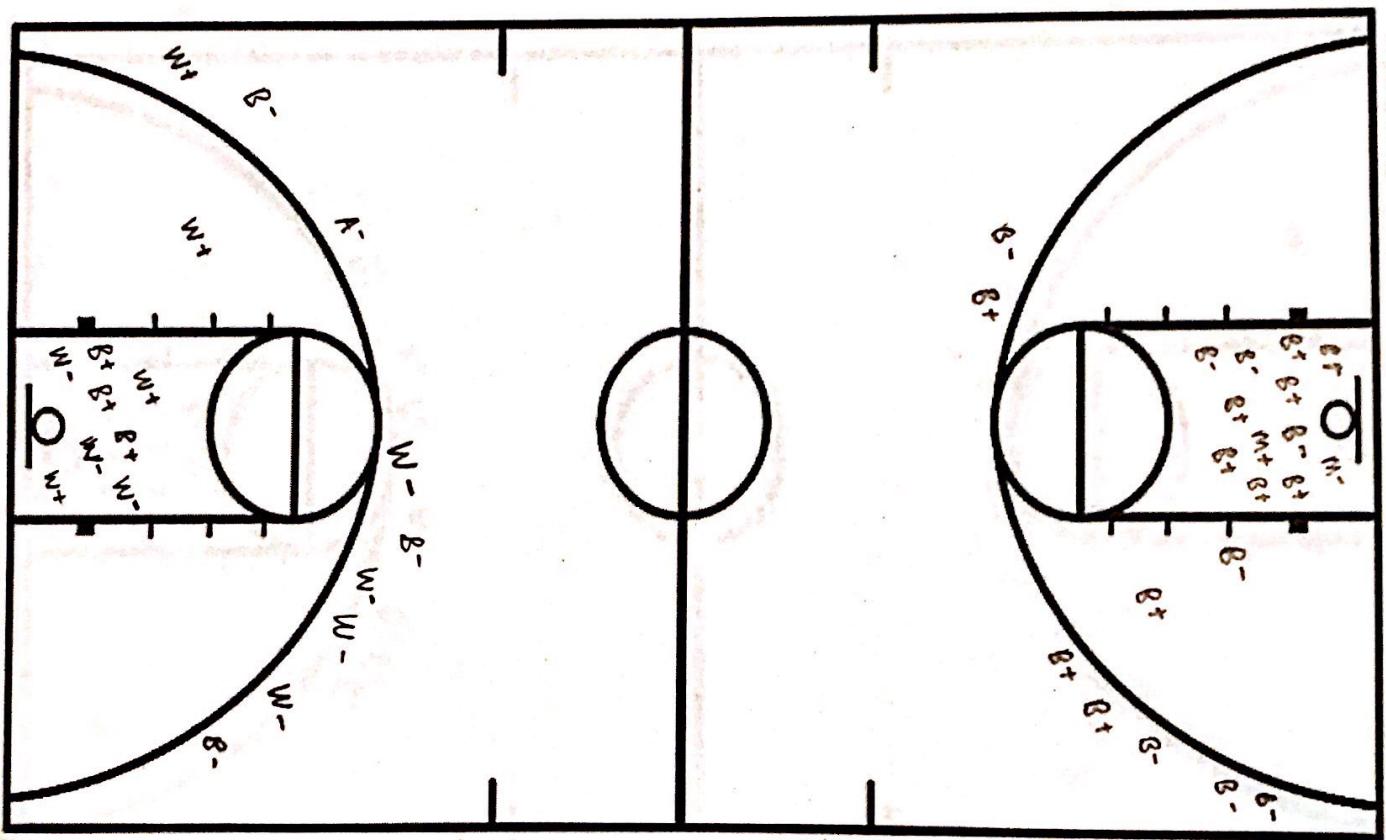
REFERENCES

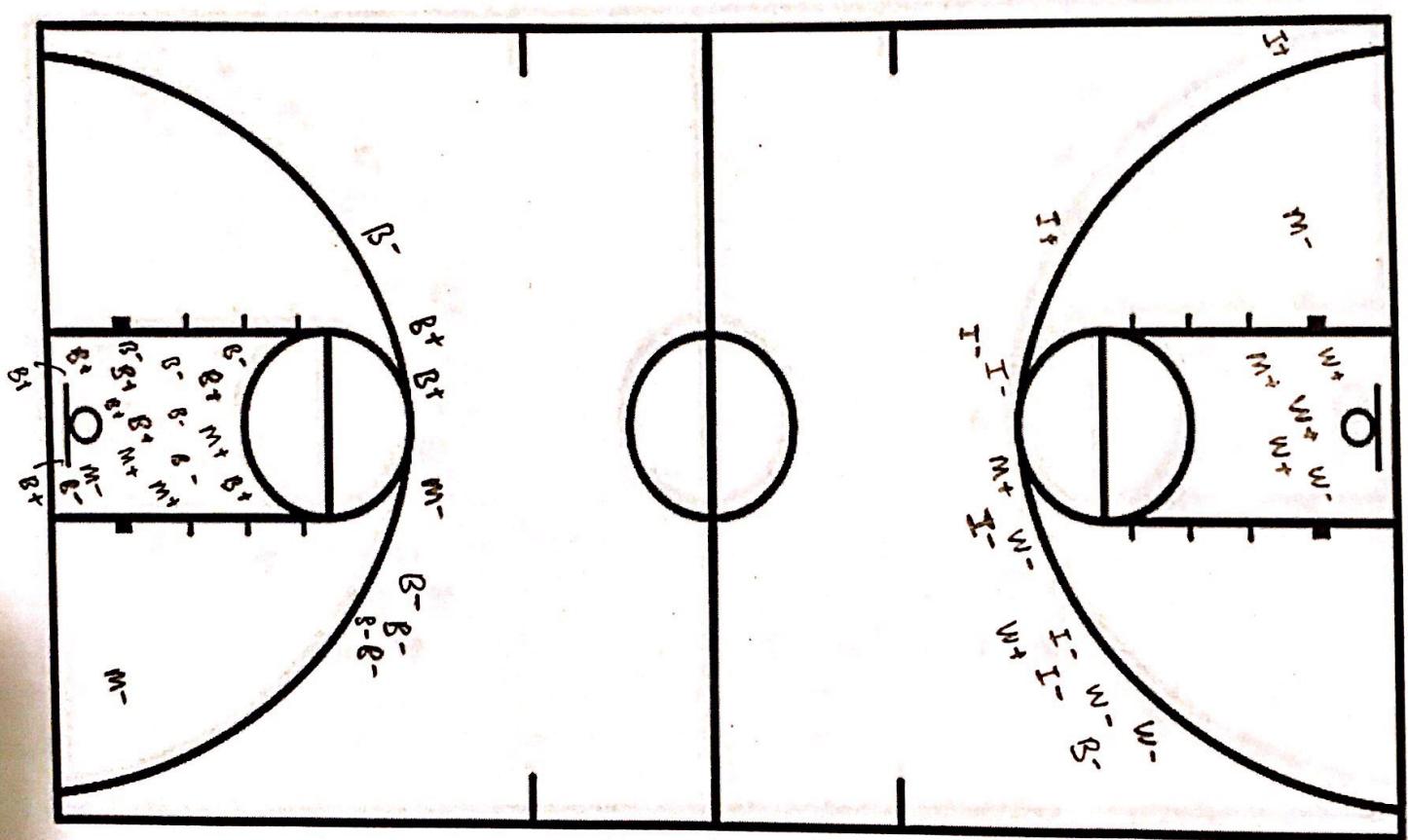
1. <https://shottracker.com/articles/the-3-point-revolution>

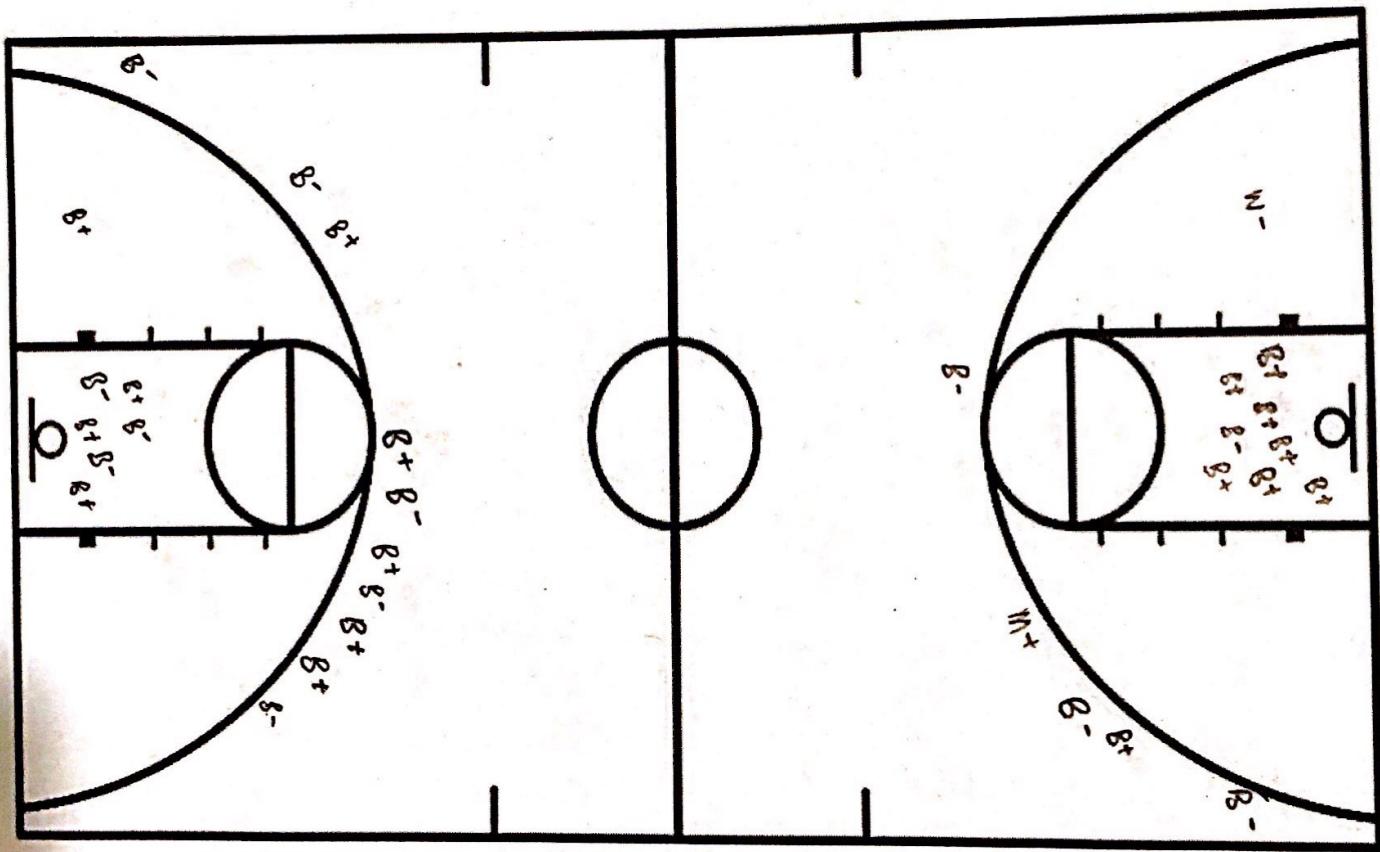




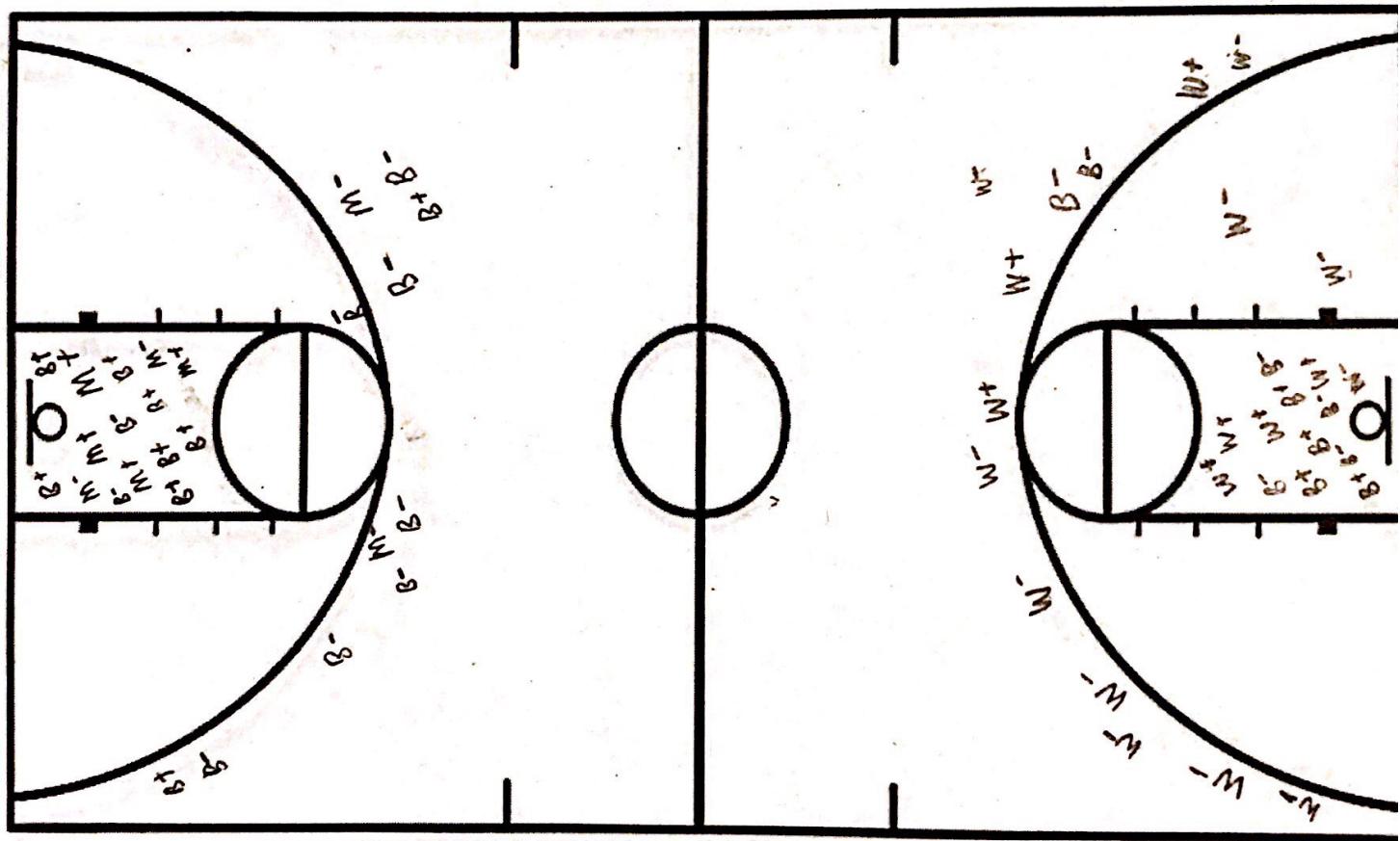


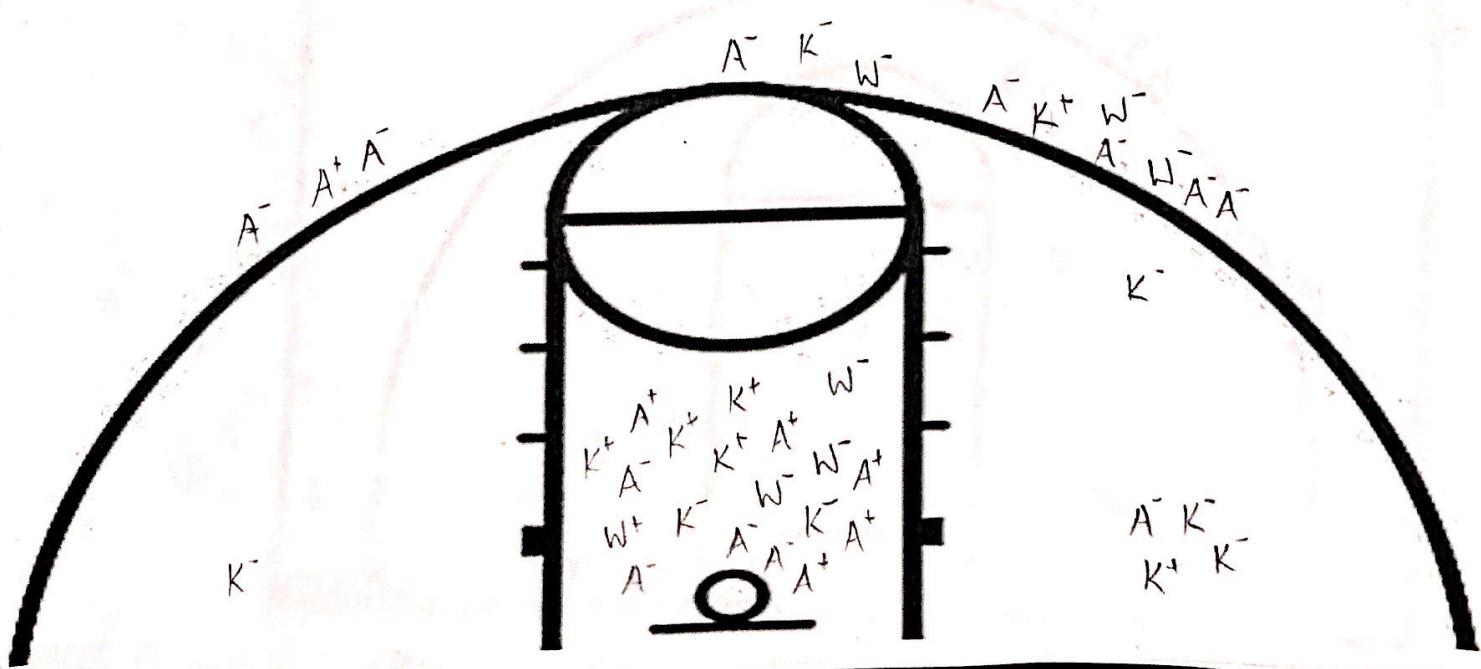
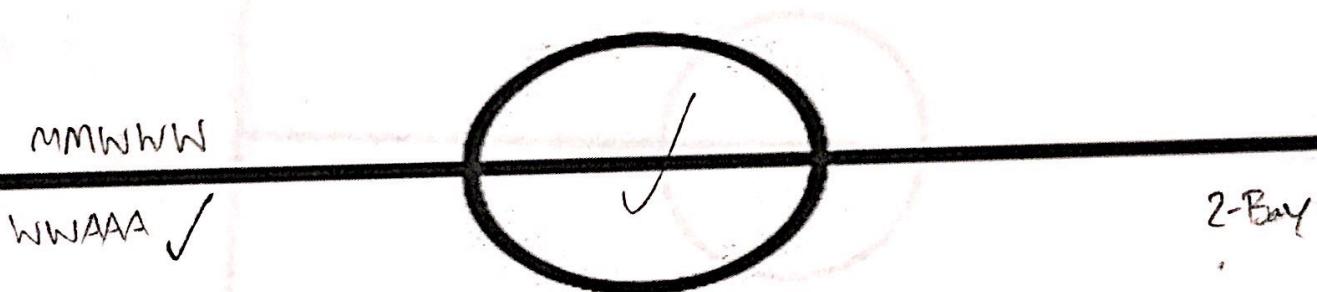
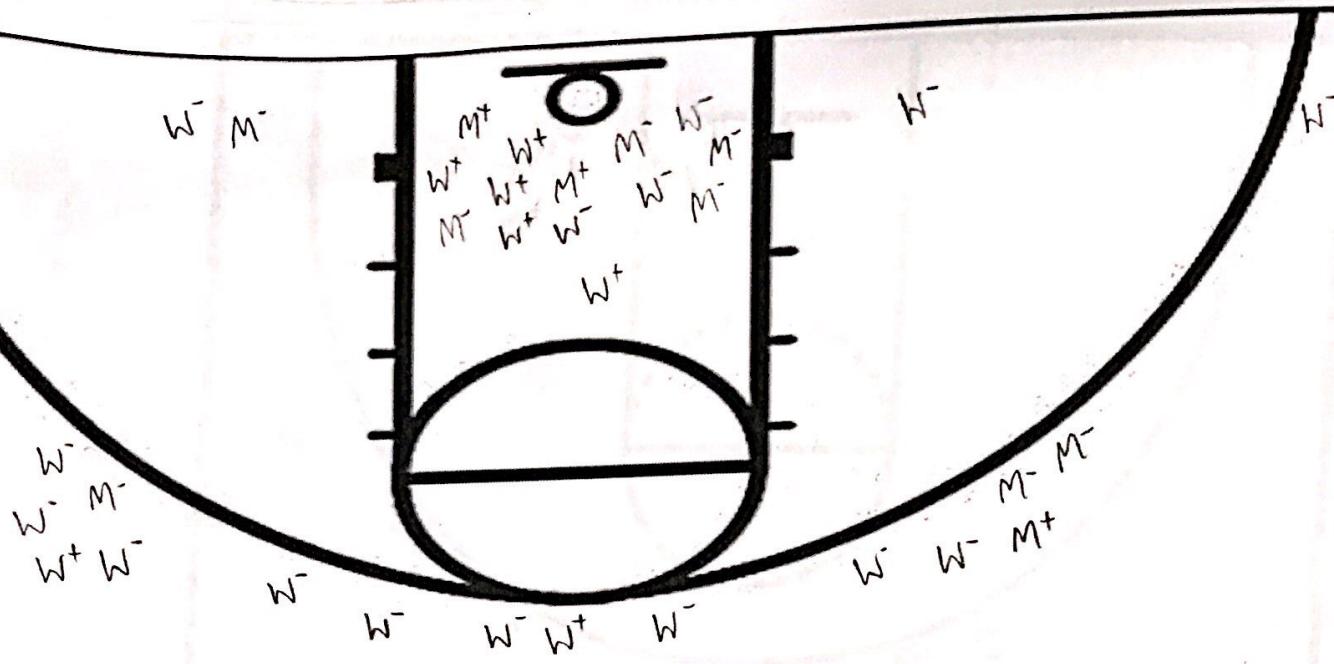






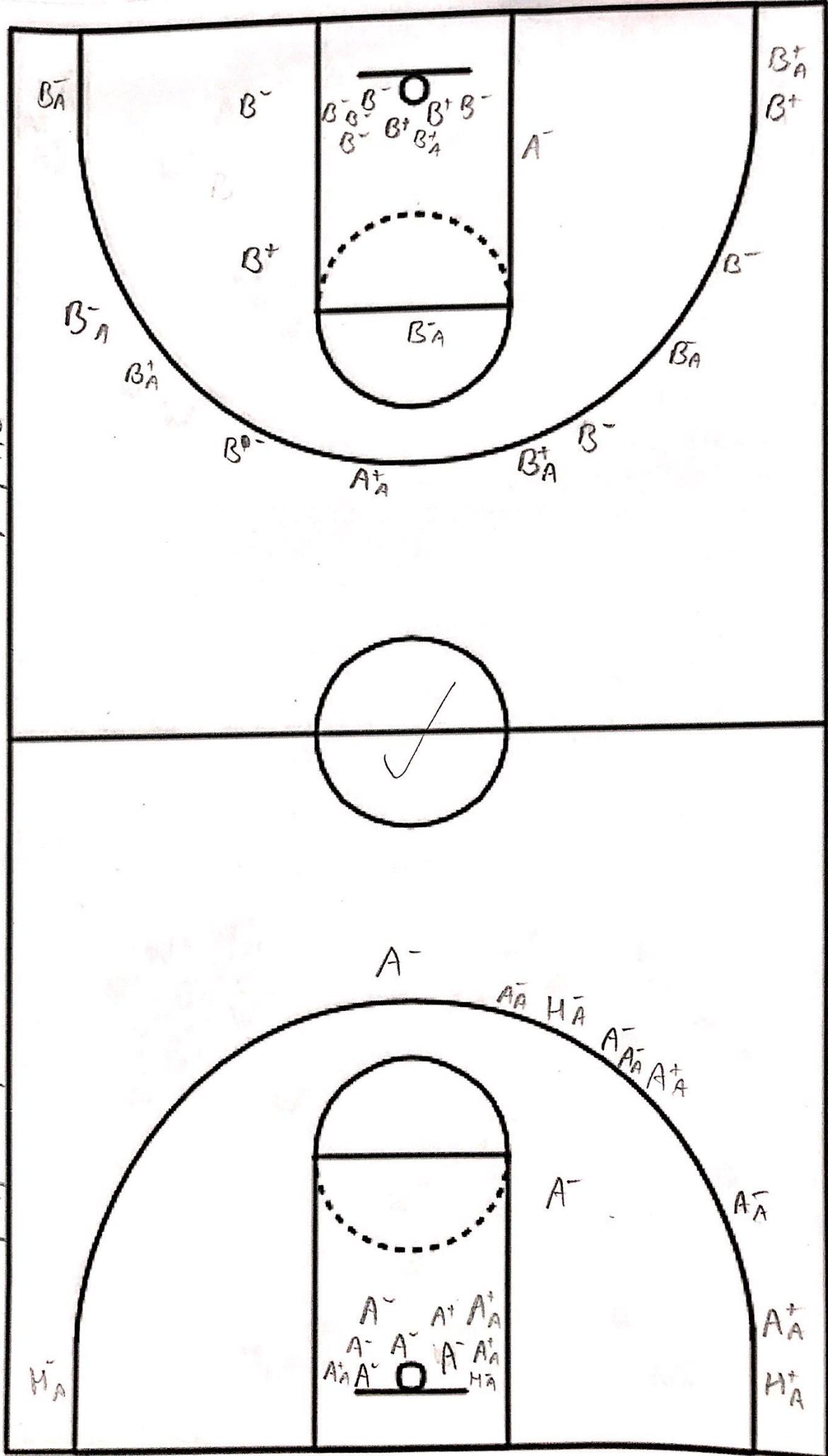
Two-Bay





A, H, AA, A

B, B, B, A, B

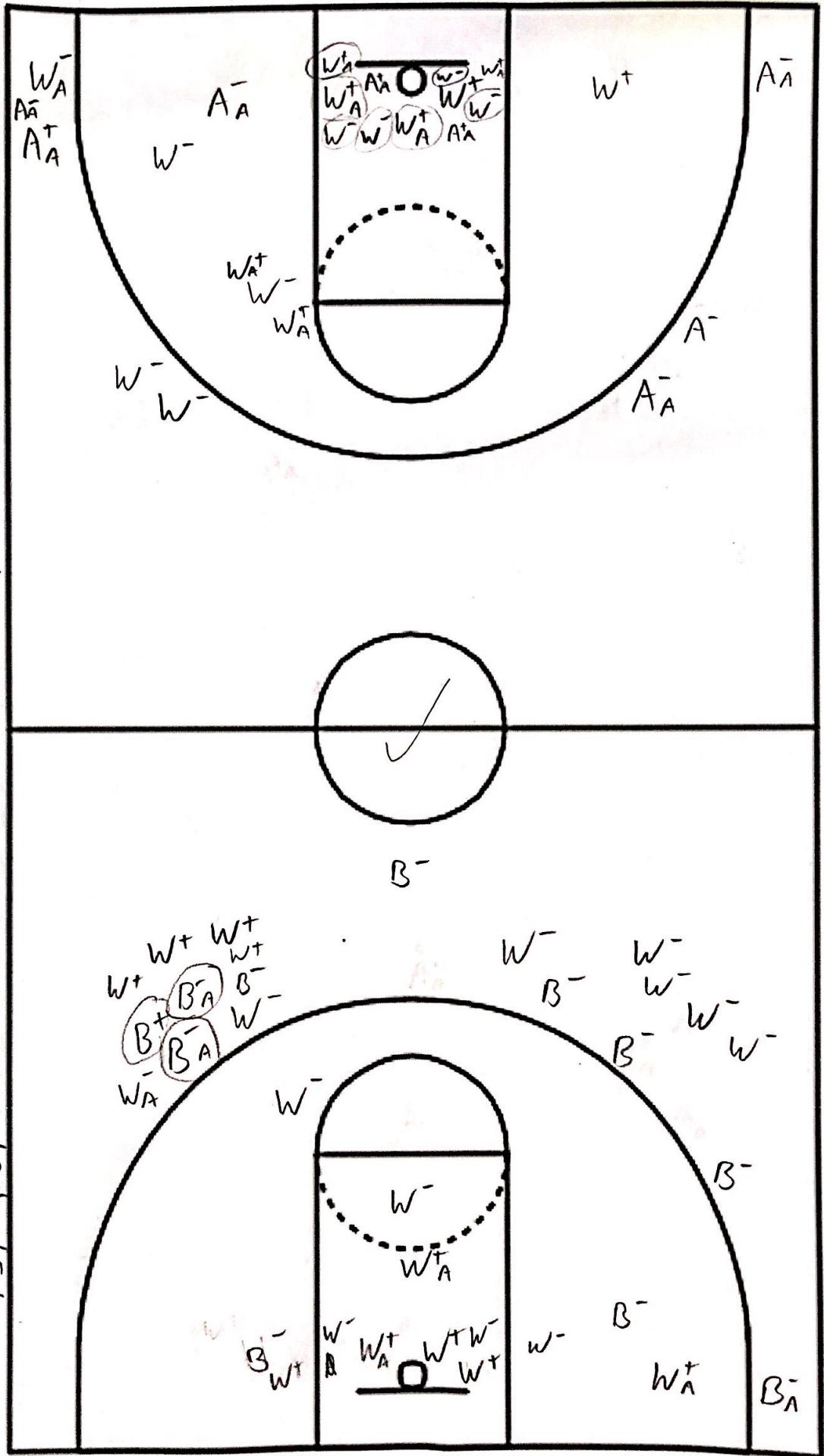


G1] 2-boy, Right

Composition.

B, B, W, B, W

W, W, A, A, W



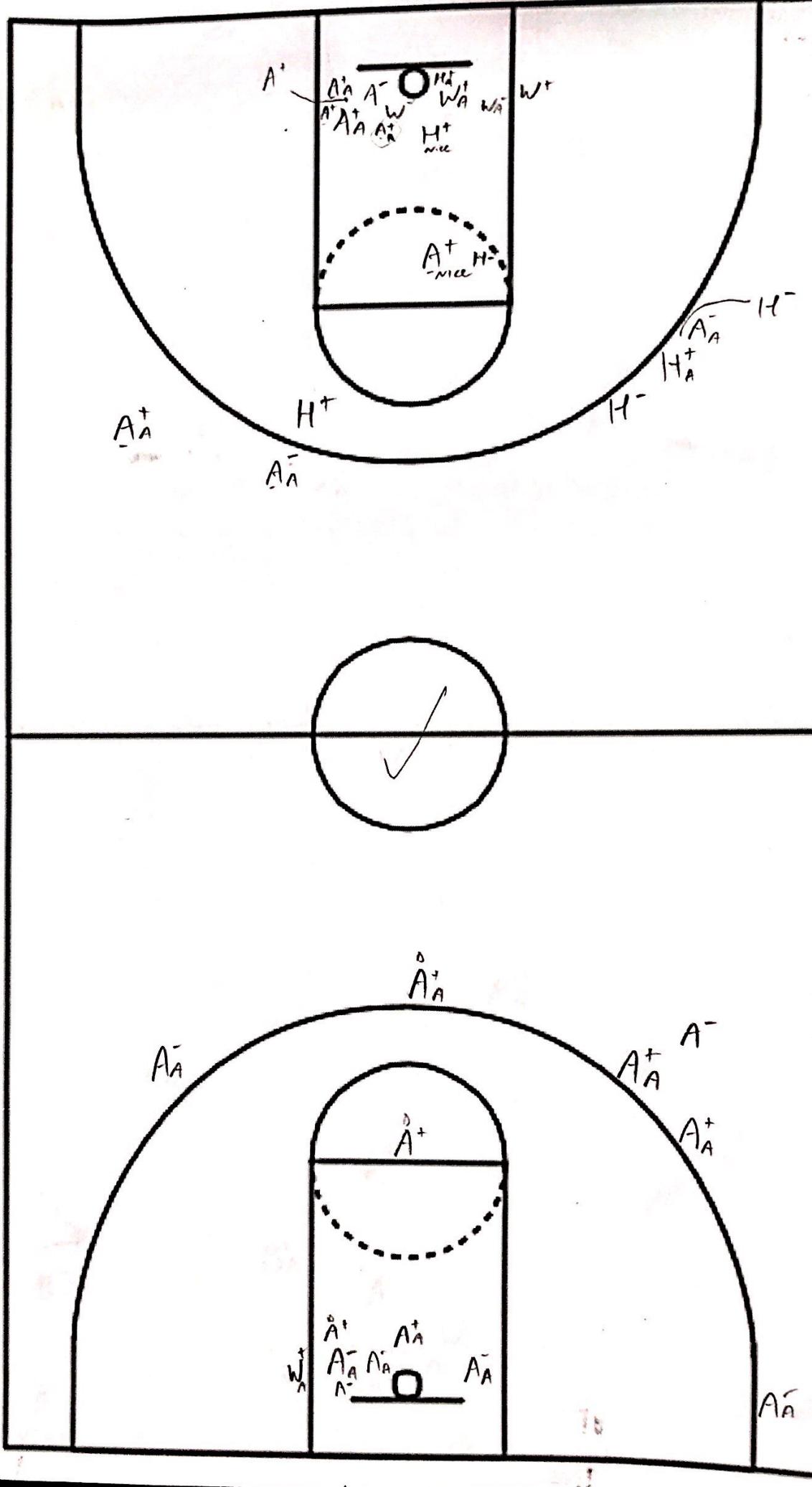
2-day, left

3:51 → 4:02

Jan 3

A,A,A,W,A

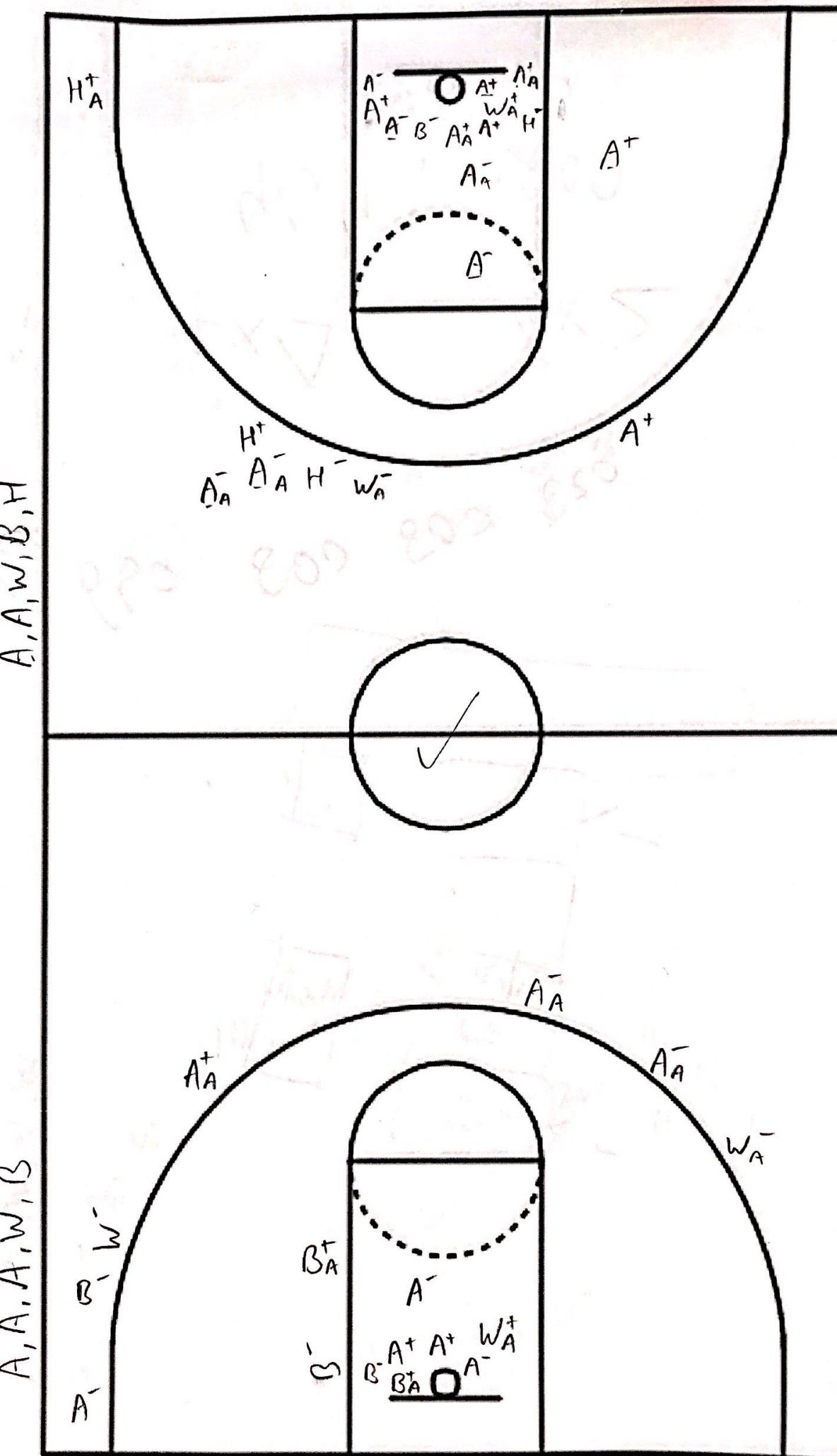
A, A, W, B, H



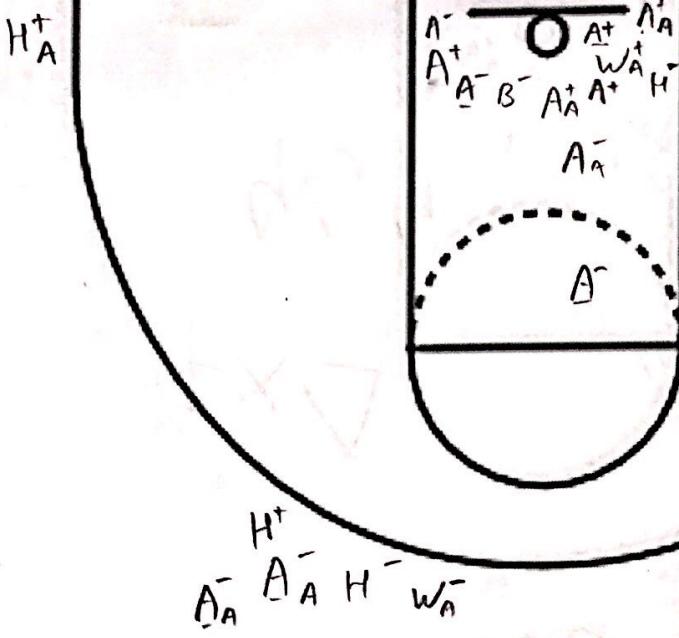
2-day, left

Comp:

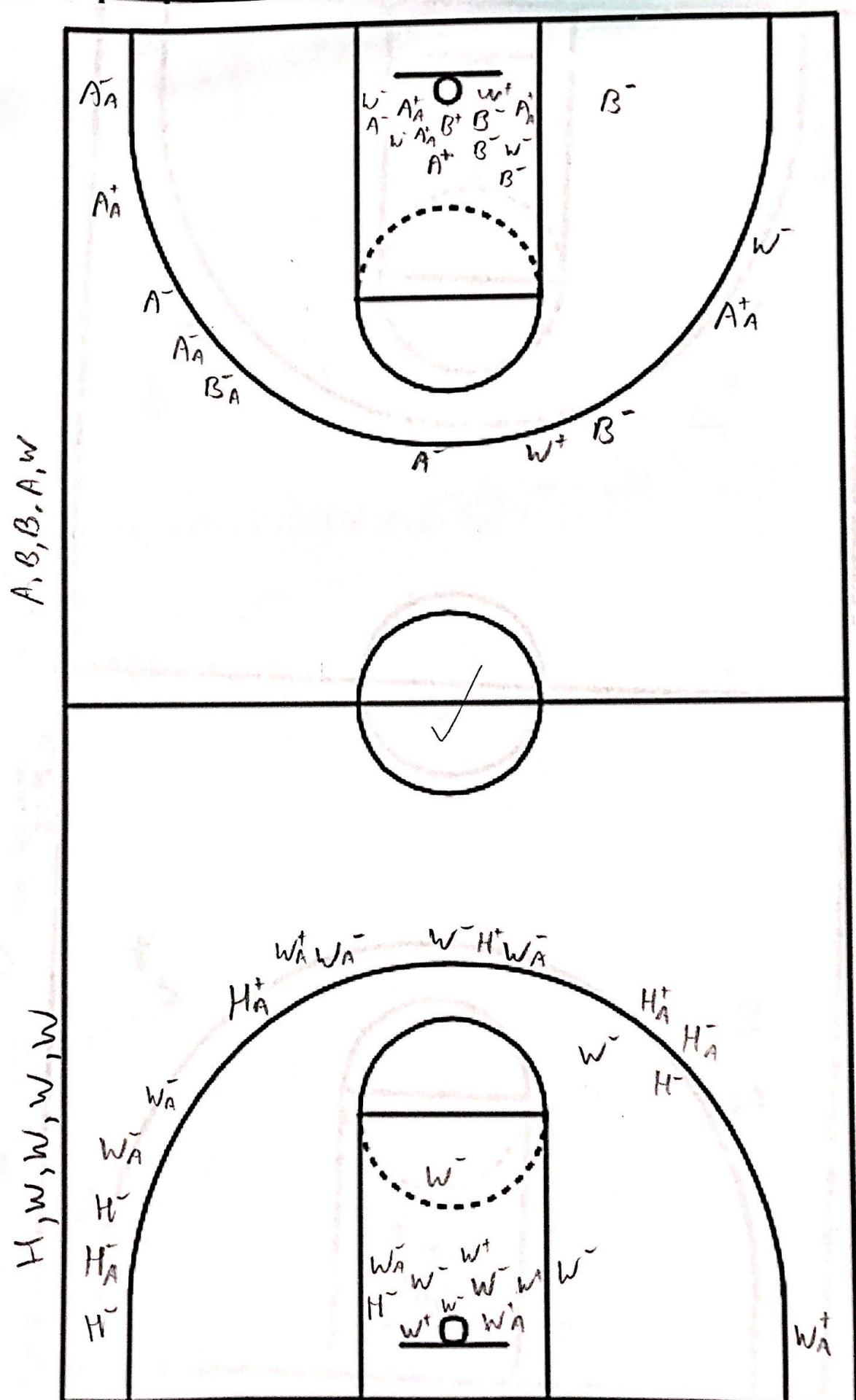
A, A, A, W, B



A, A, W, B, H



2 - bay, right



(54) β -Buy, Middle
4:07 → 4:22

w^+ , w^- , w^+ , β

Hols tall white
guy #16 3's

w_A^+ B_A^-
 w^+

B_A^+ B_A^-
 w_A^+ w_A^-
 w_A^+ w_A^-

w^+

w^+ w^-
 w^+ w^-

Asian court



w^+ , w^- , β , H , w

β^-

w_A^+

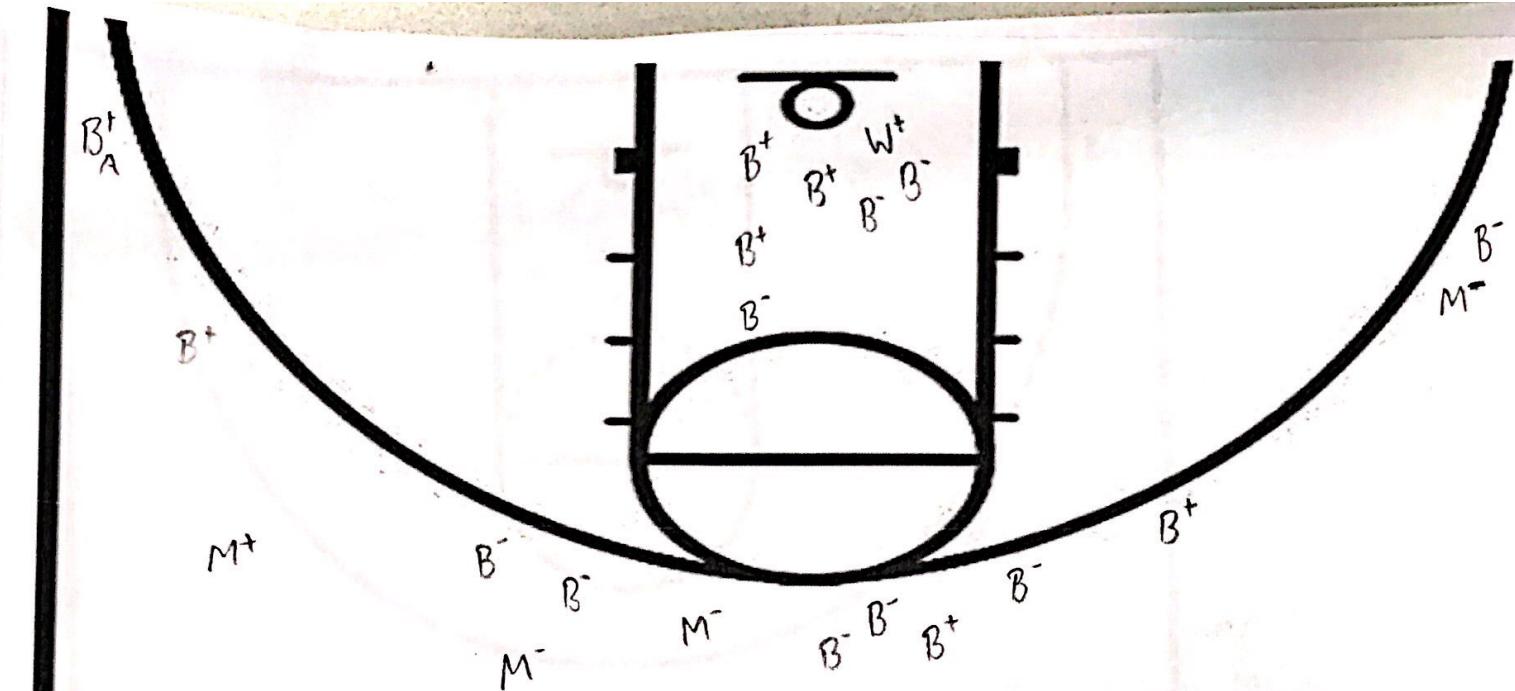
H^-

w^-

β^-
 H^+
 B_A^+ H^-
 O
 B_A^+ H^+

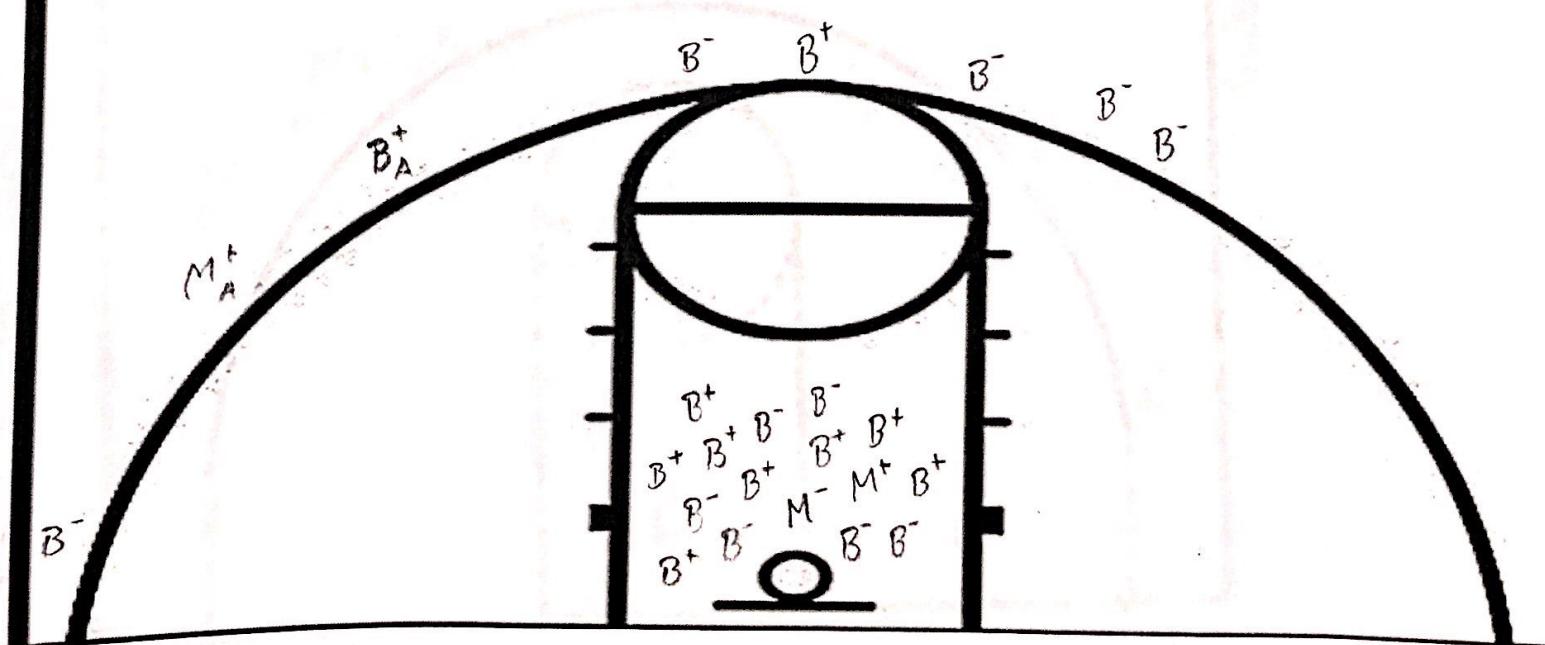
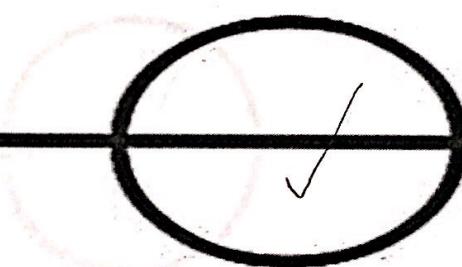
H^+
 $H \cdot w_A^+$
 w^-

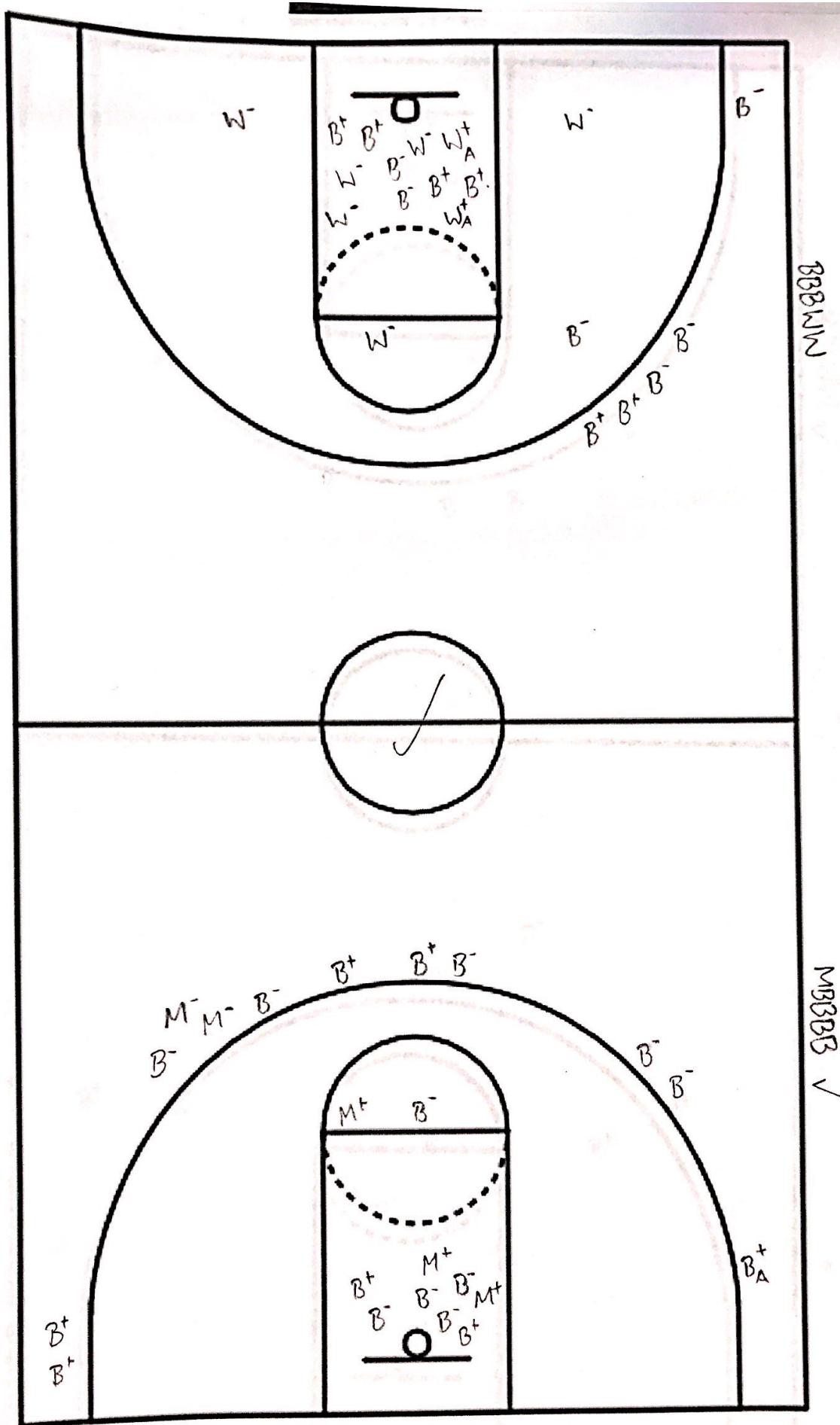
w_A^+ w^-
 w_A^+ w^-

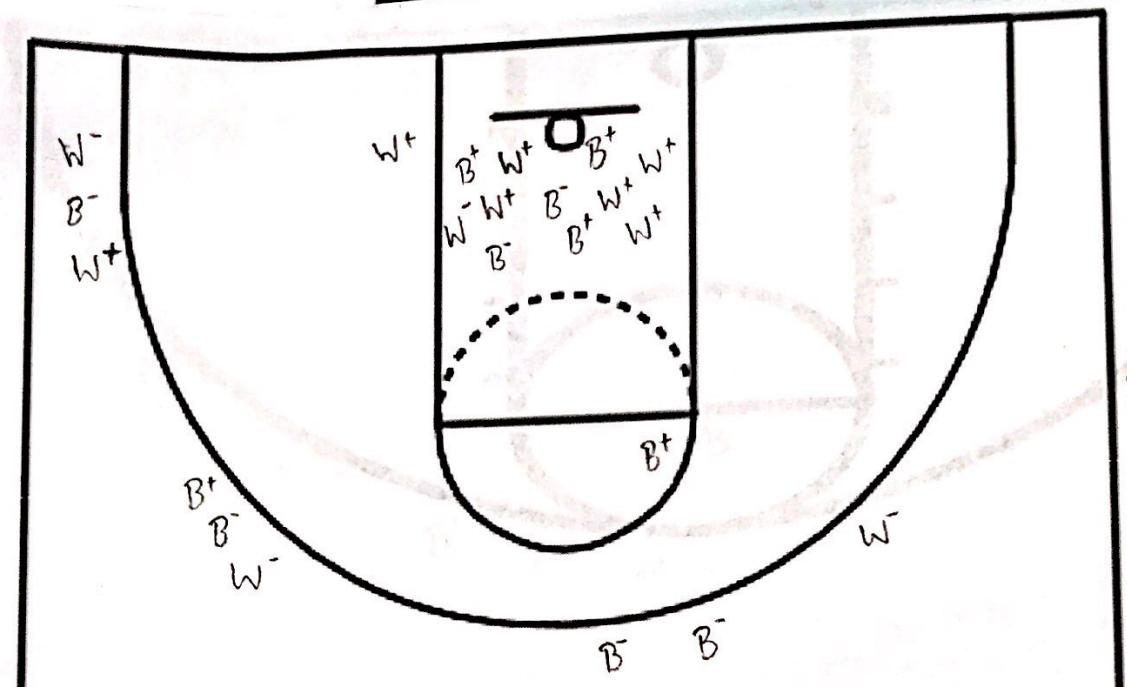


3-Bay Bt Count
MBBBB \checkmark

BBBW M





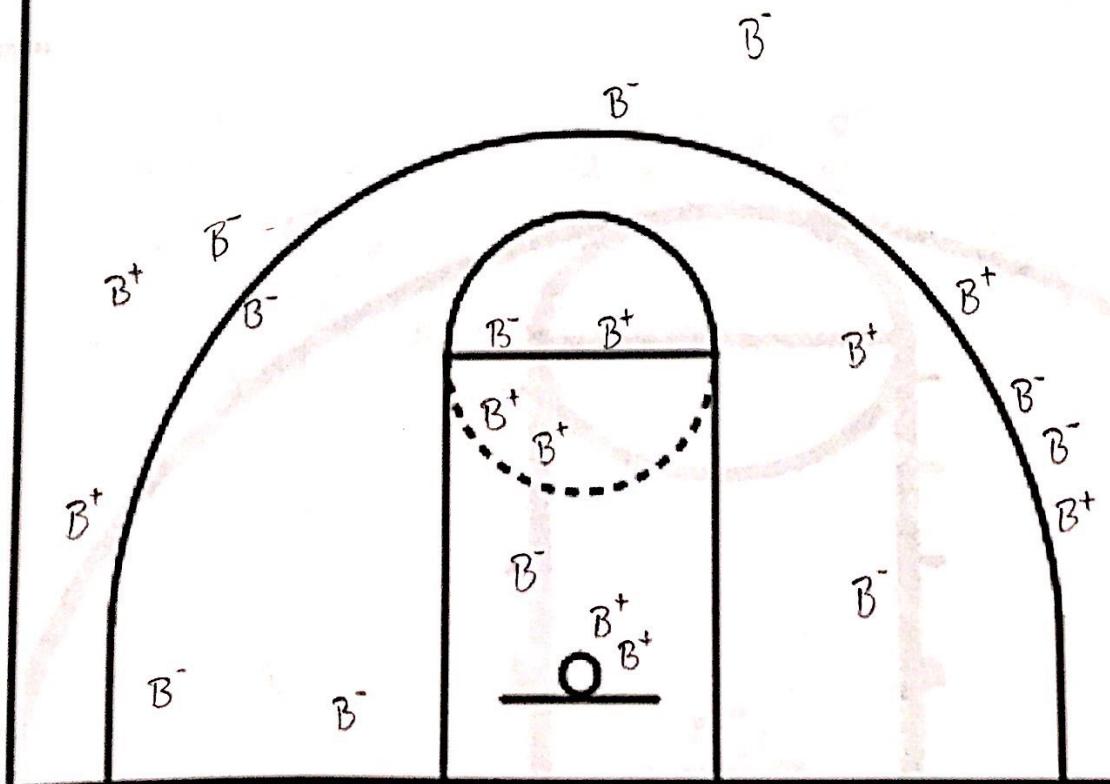


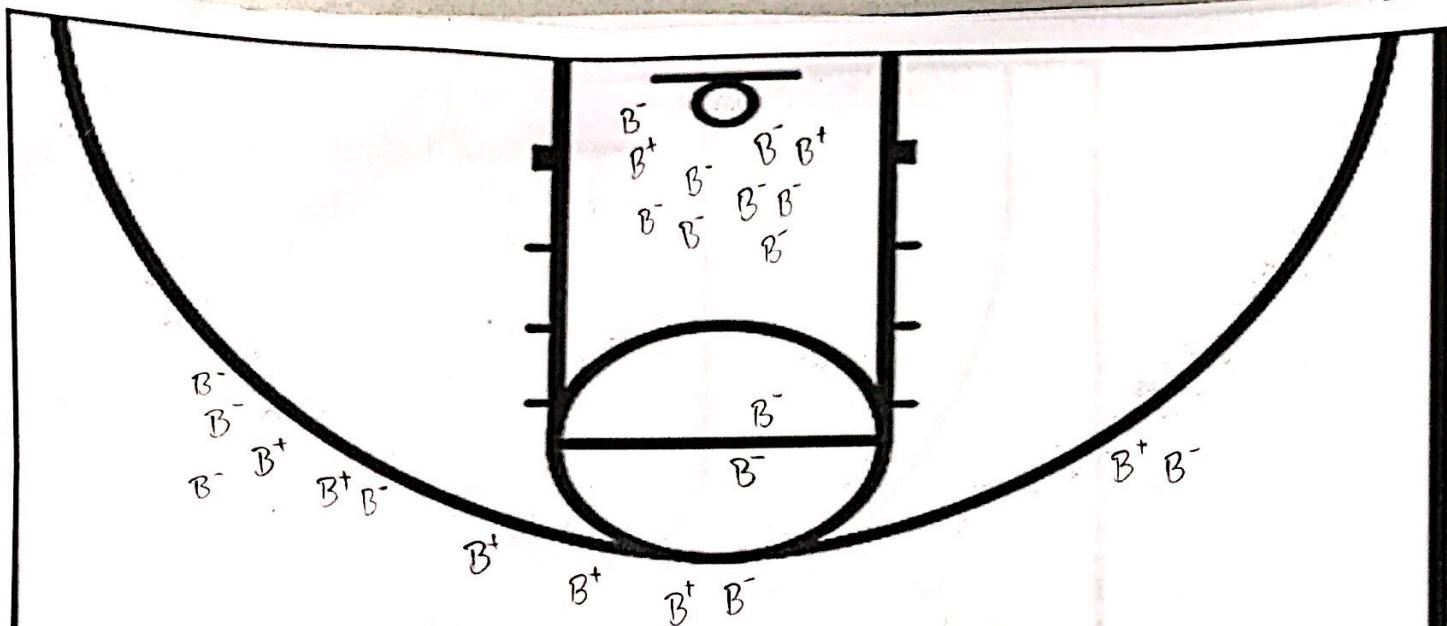
BBBWW ✓

Forgot to
record assists

3-Bay
1st Court

BBBBB



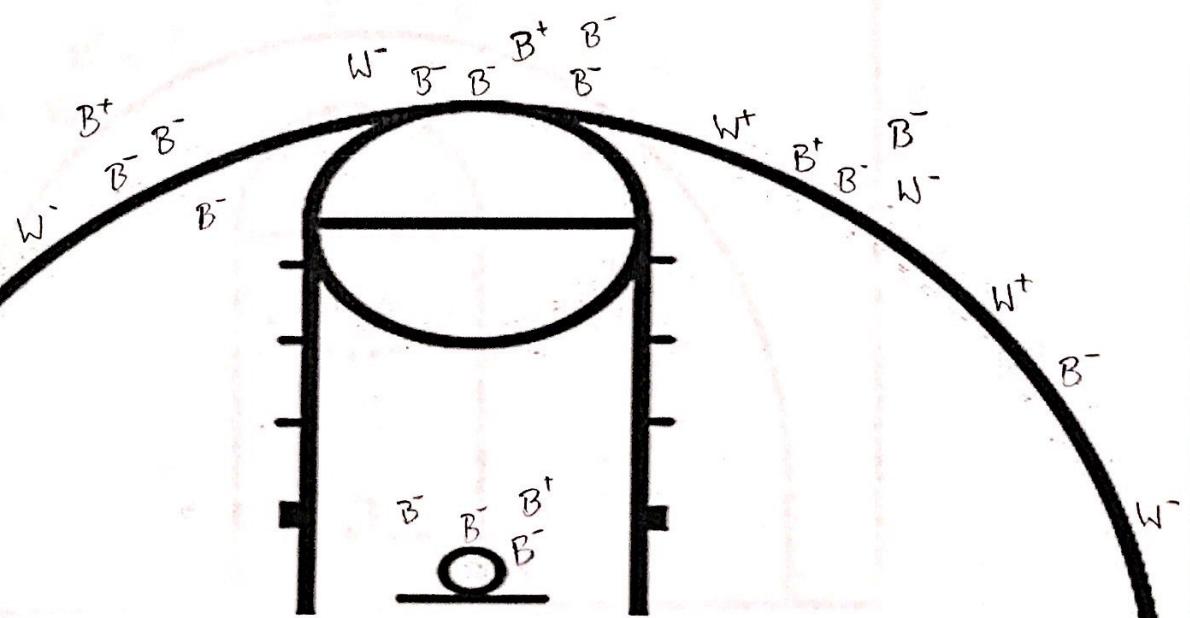


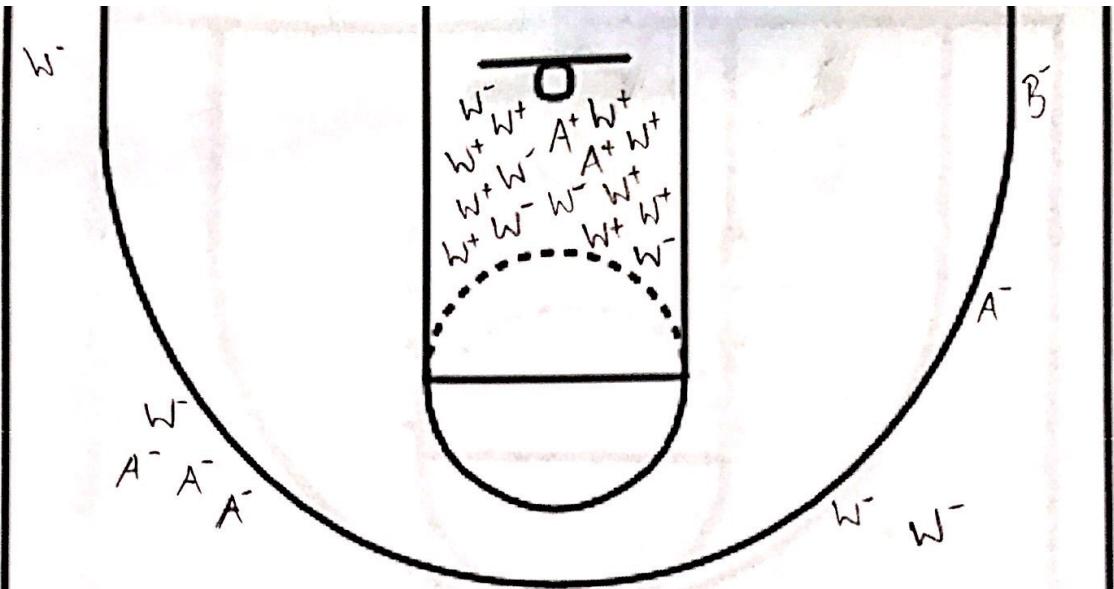
$BBB B B$ ✓

$BBWWW$

2-Bay

But really good
players
Consider counting
as 1st Court
3-Bay

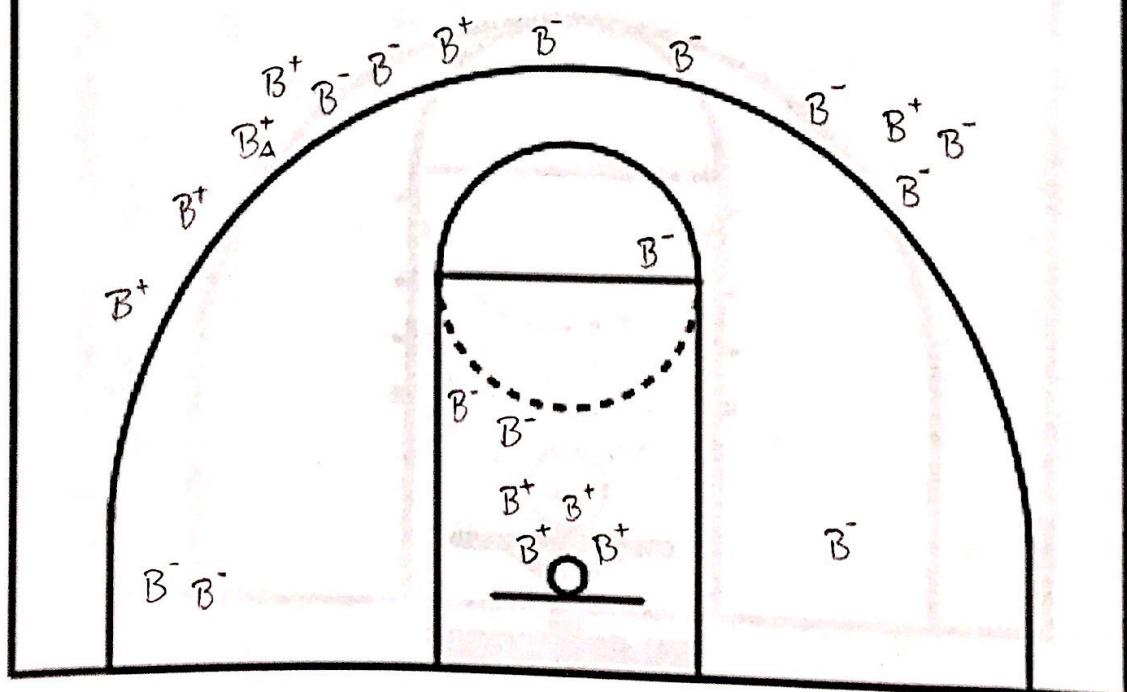
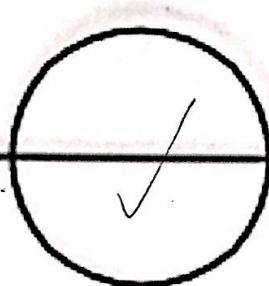




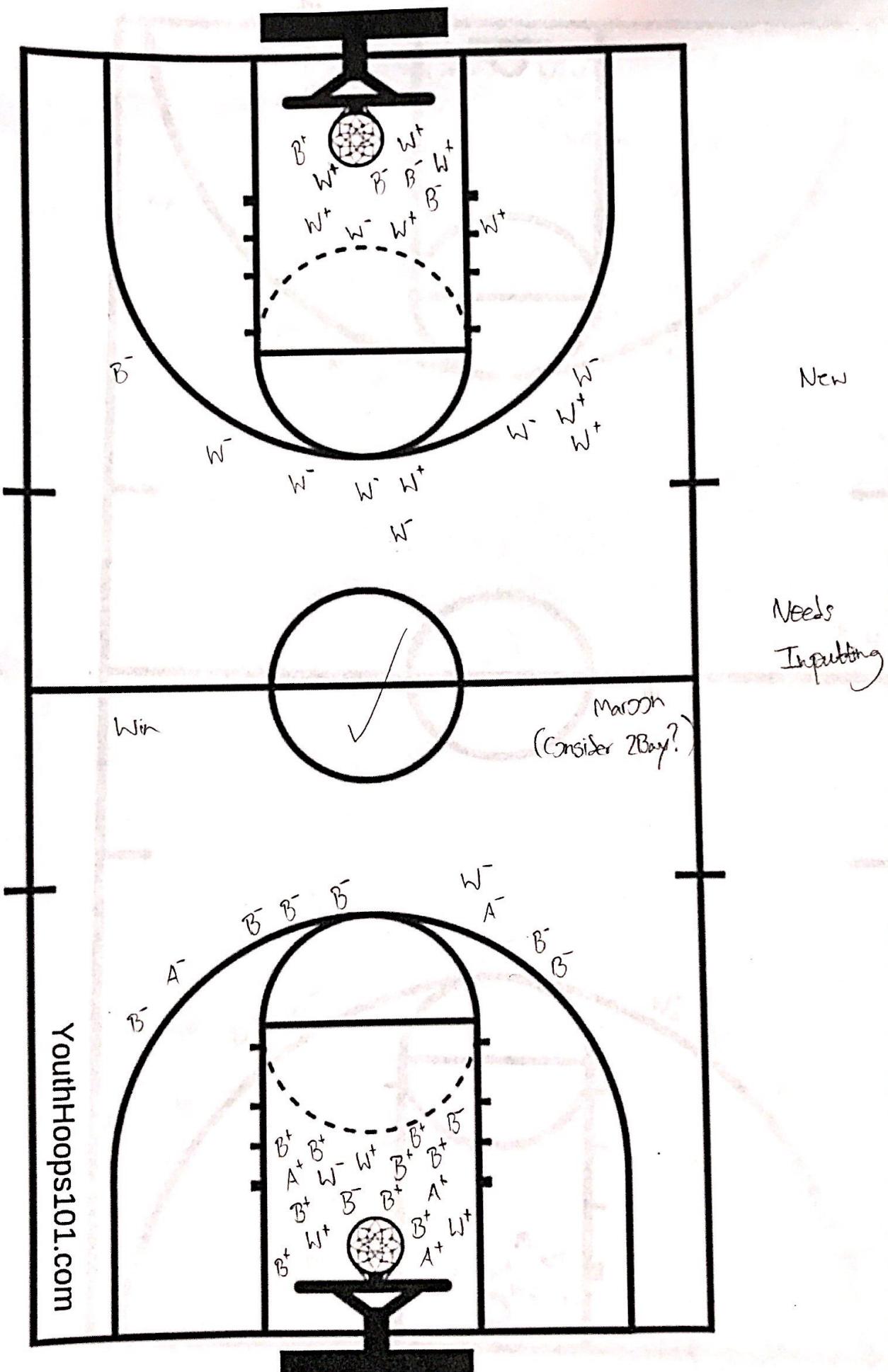
WWNAB

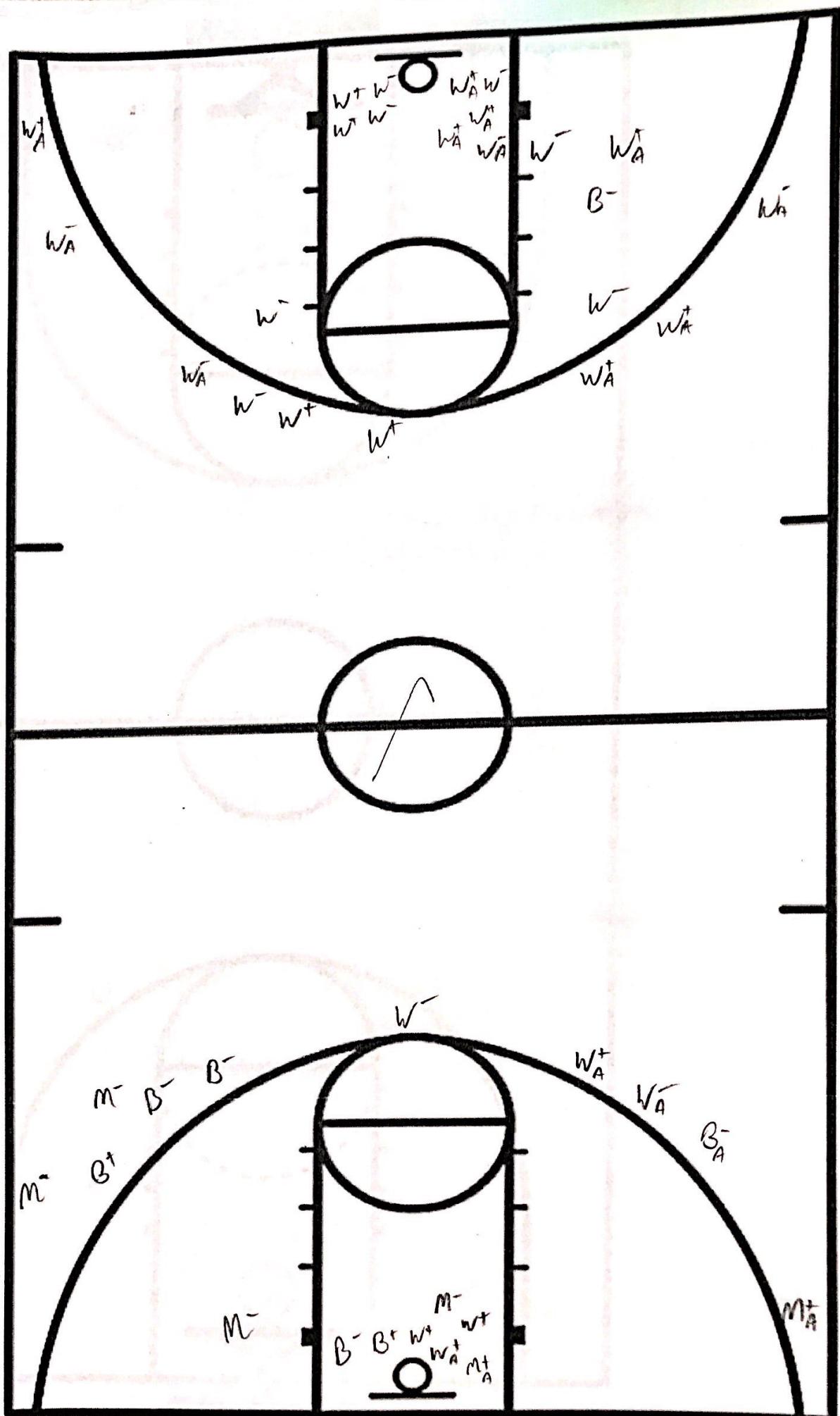
Forgot to
record assists

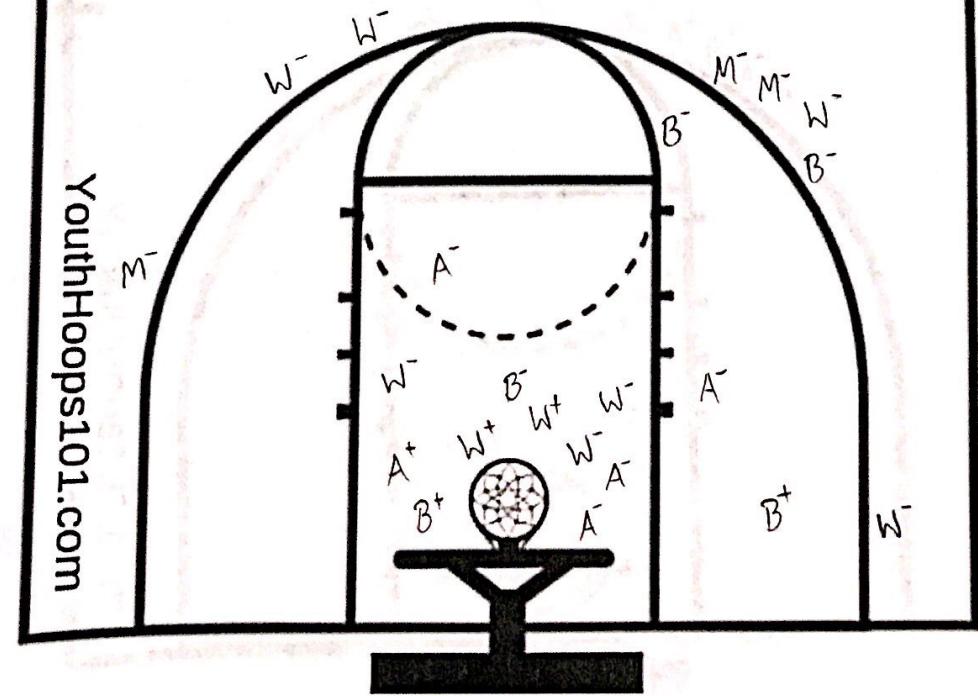
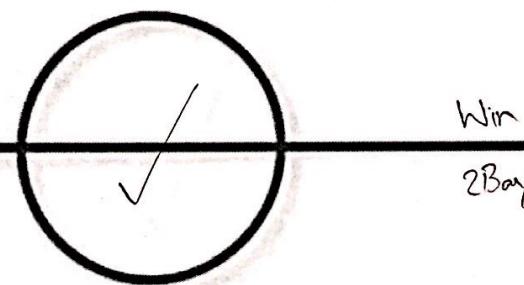
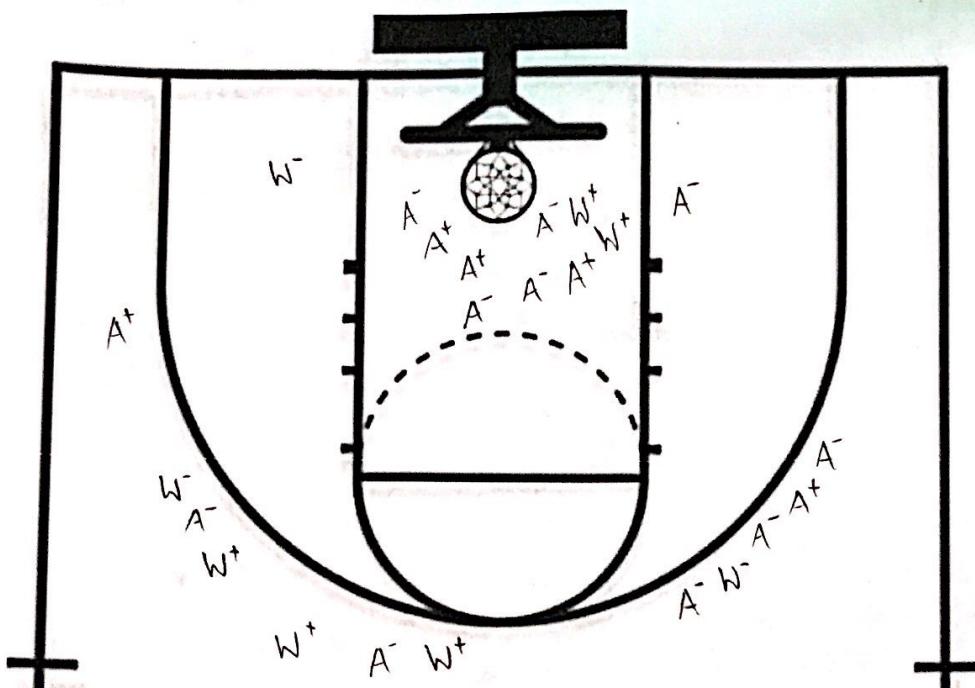
3-Bay 1st
Court



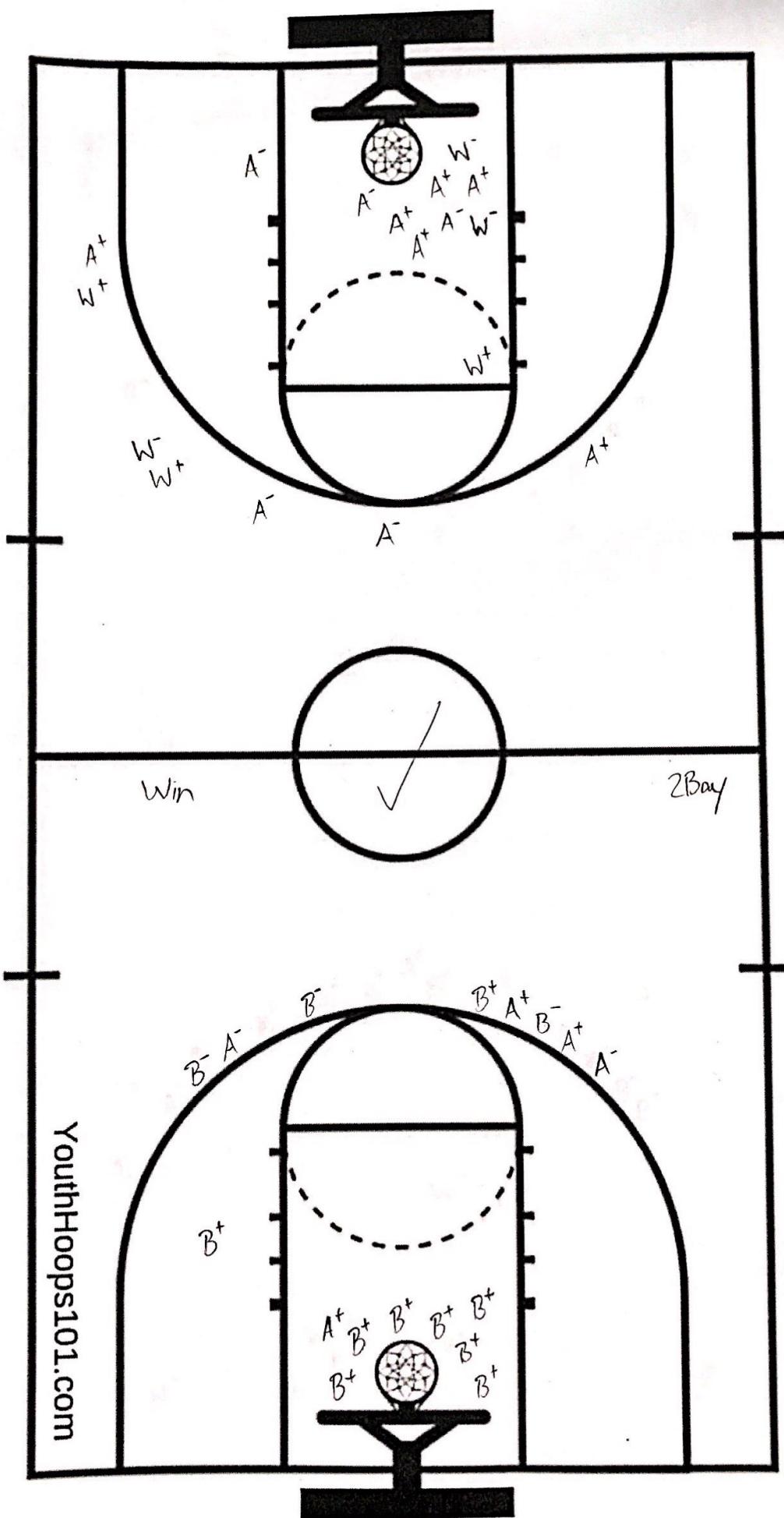
BBBBB
✓

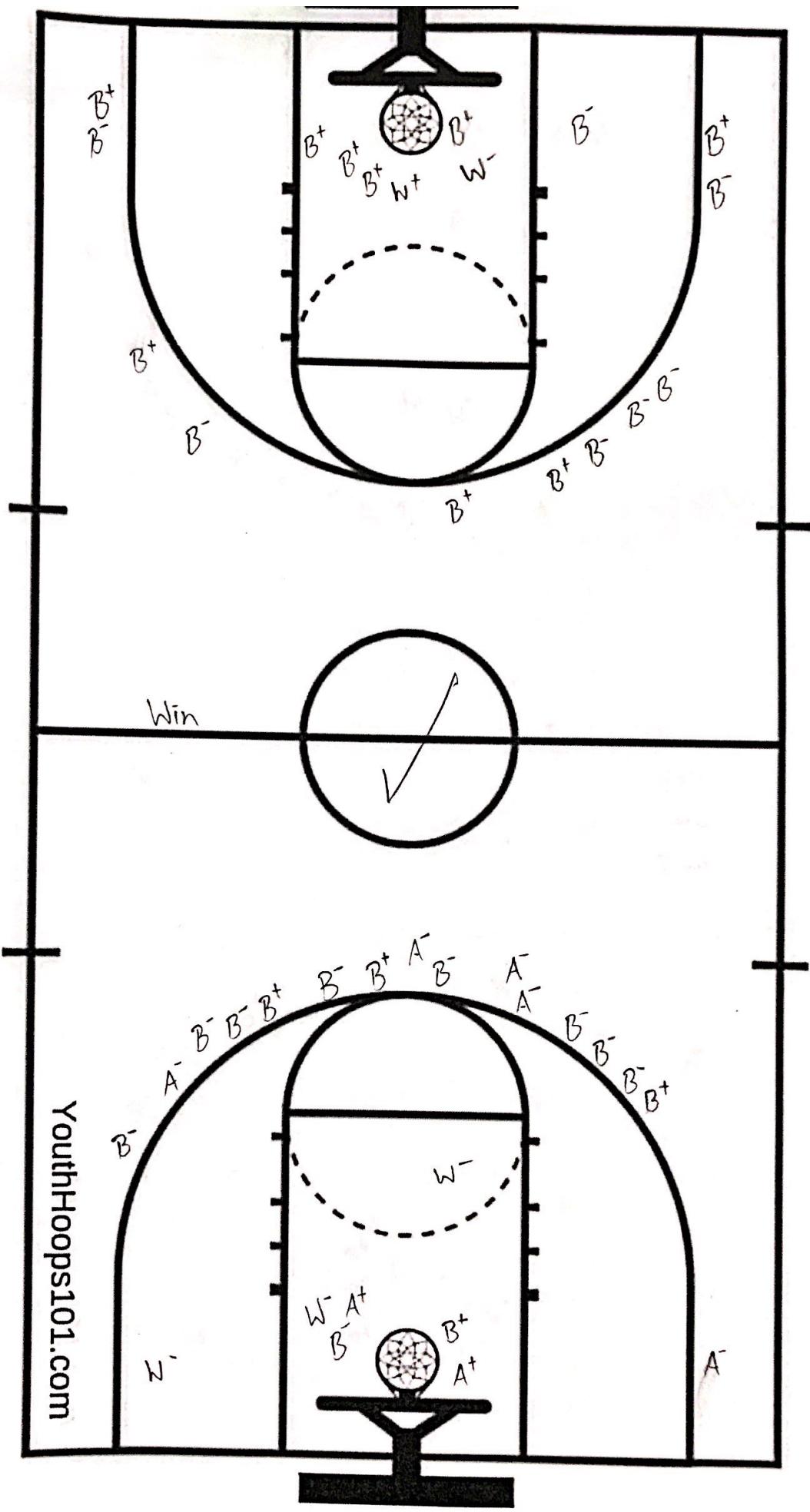


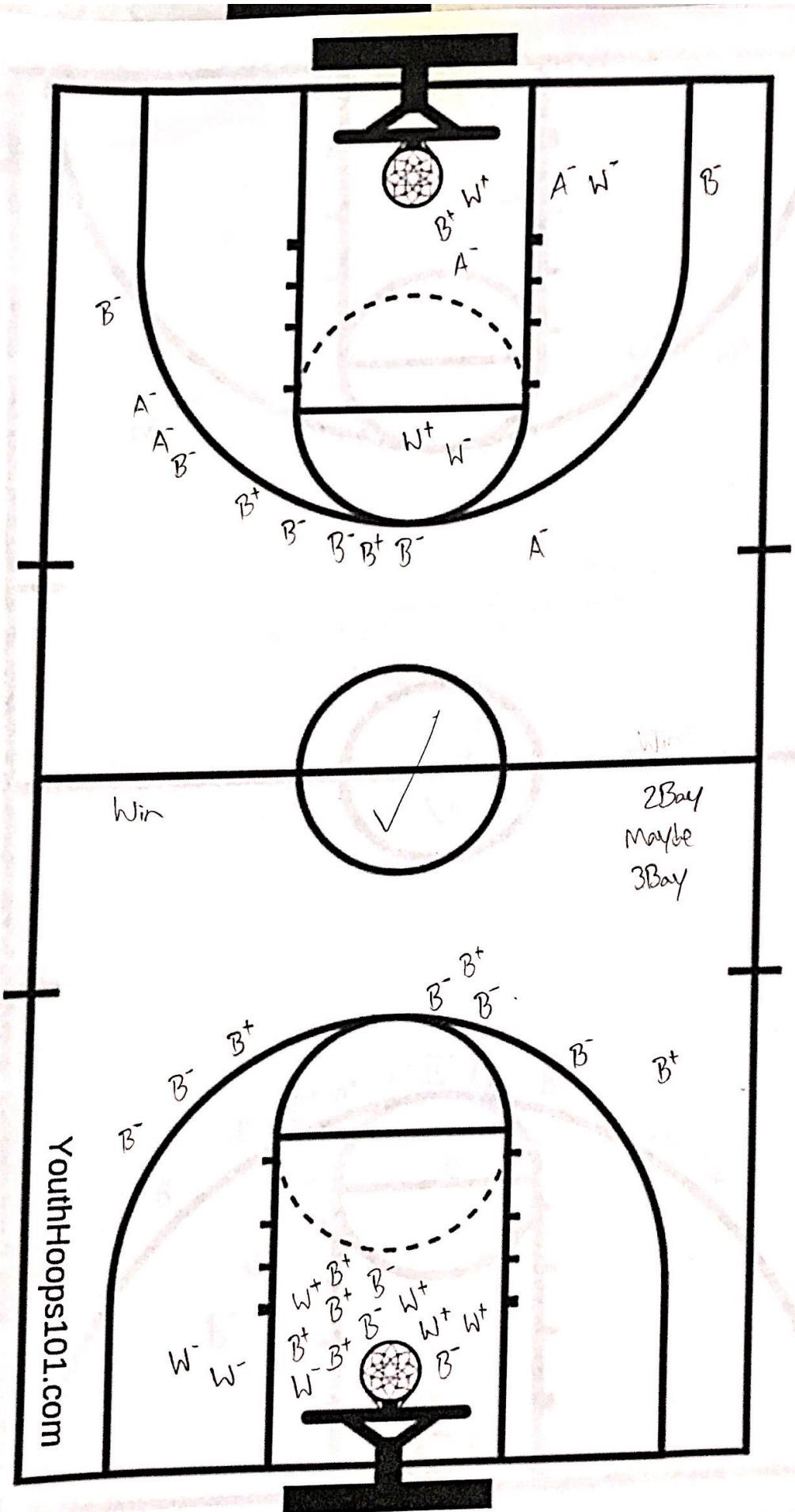


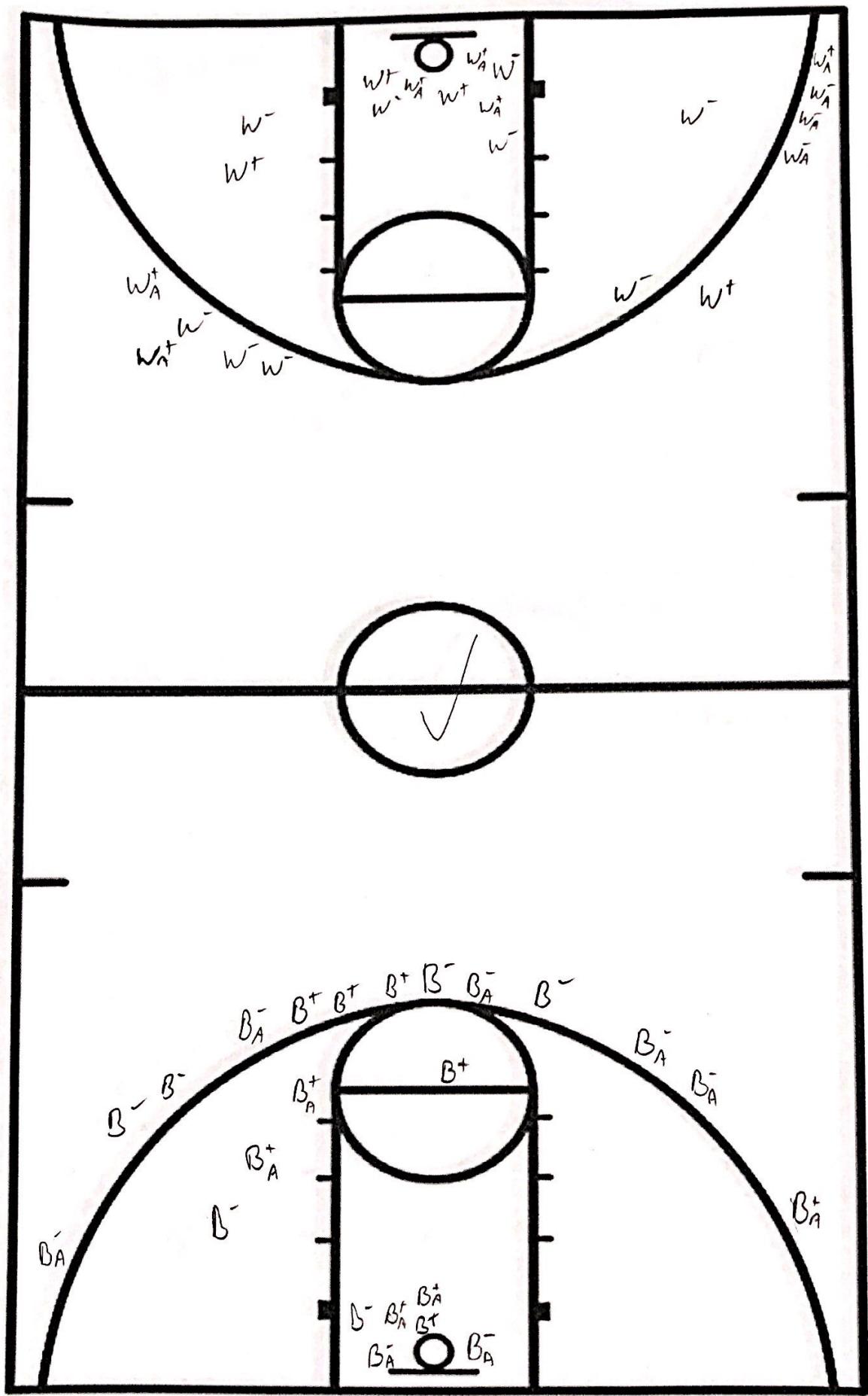


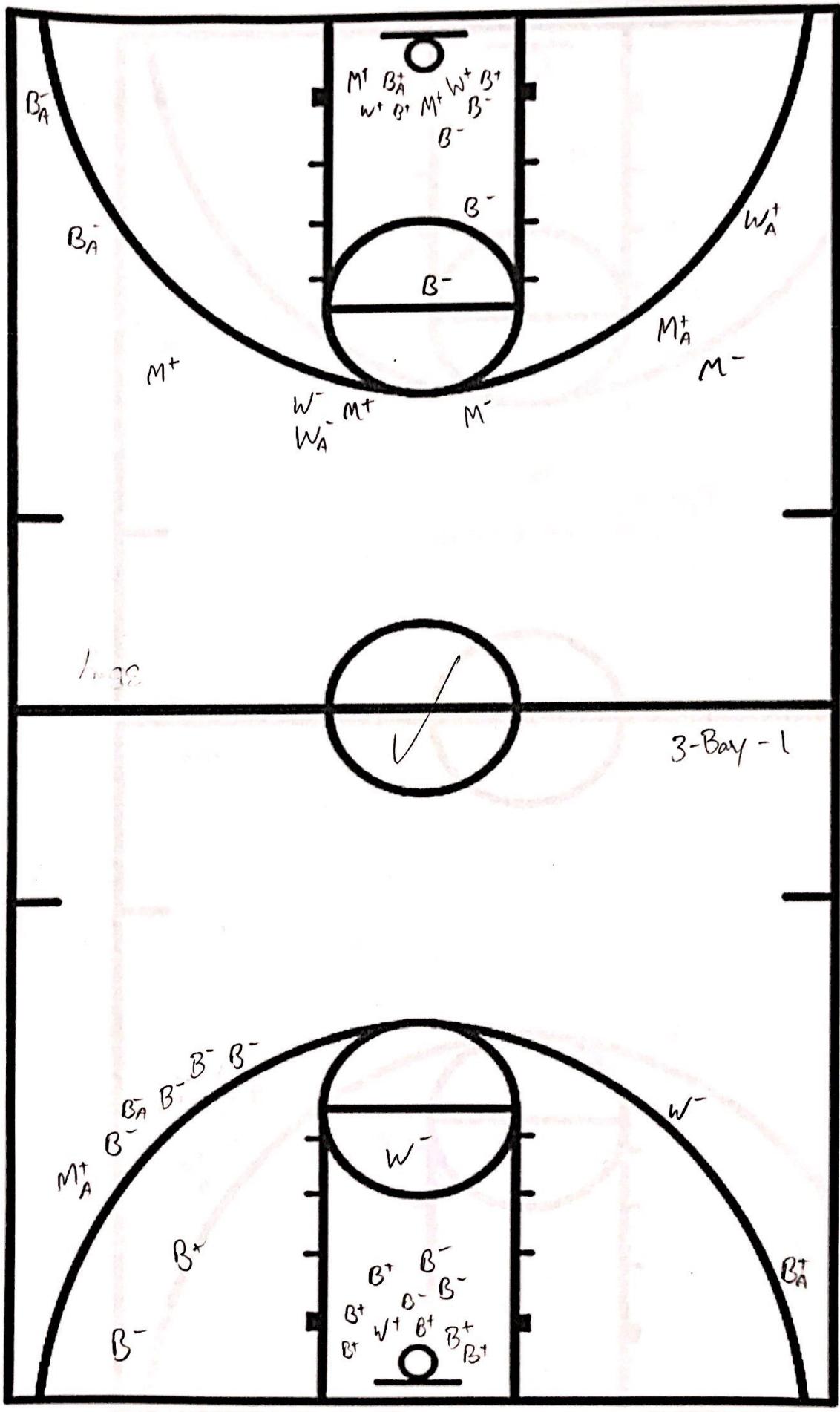
YouthHoops101.com

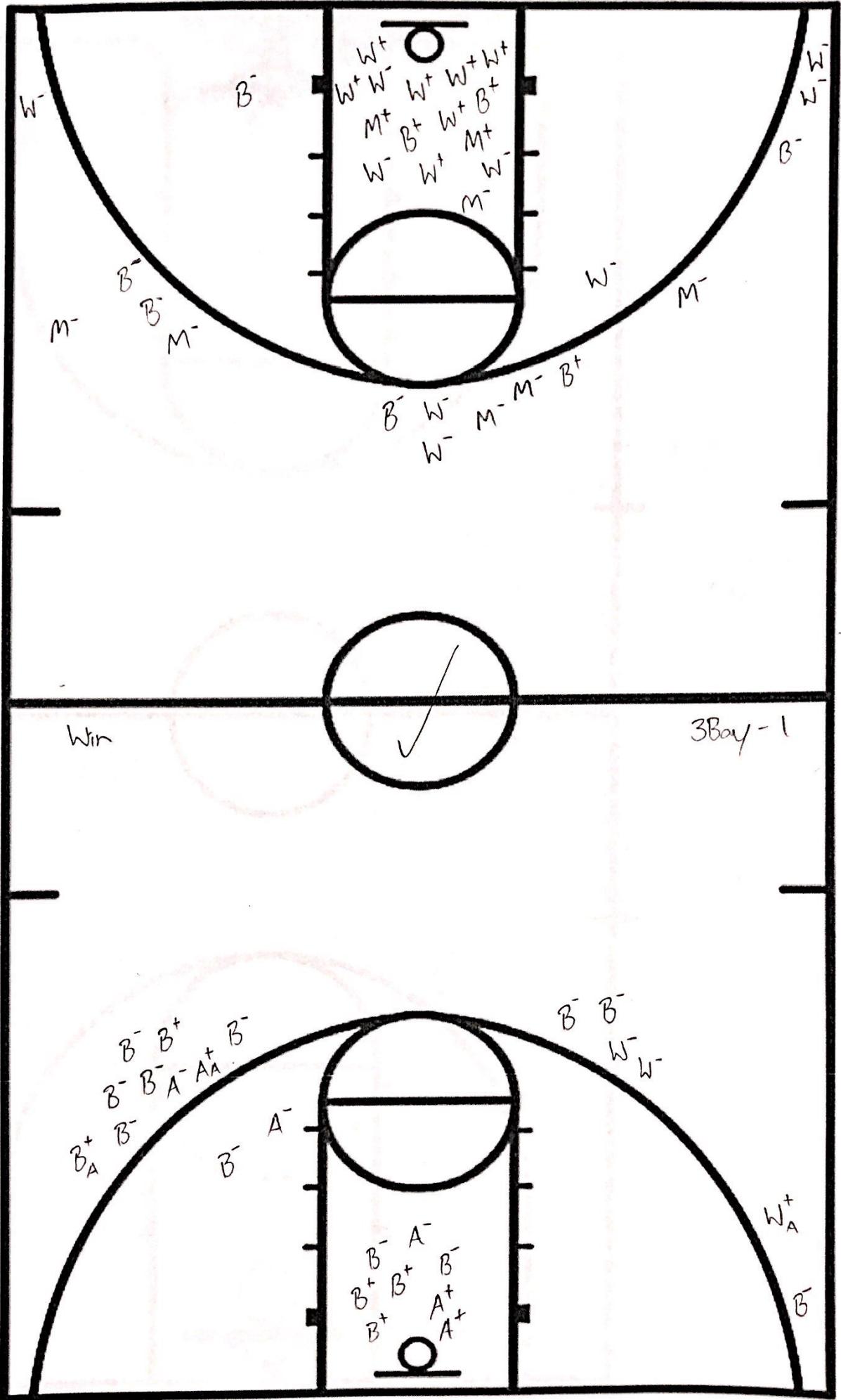


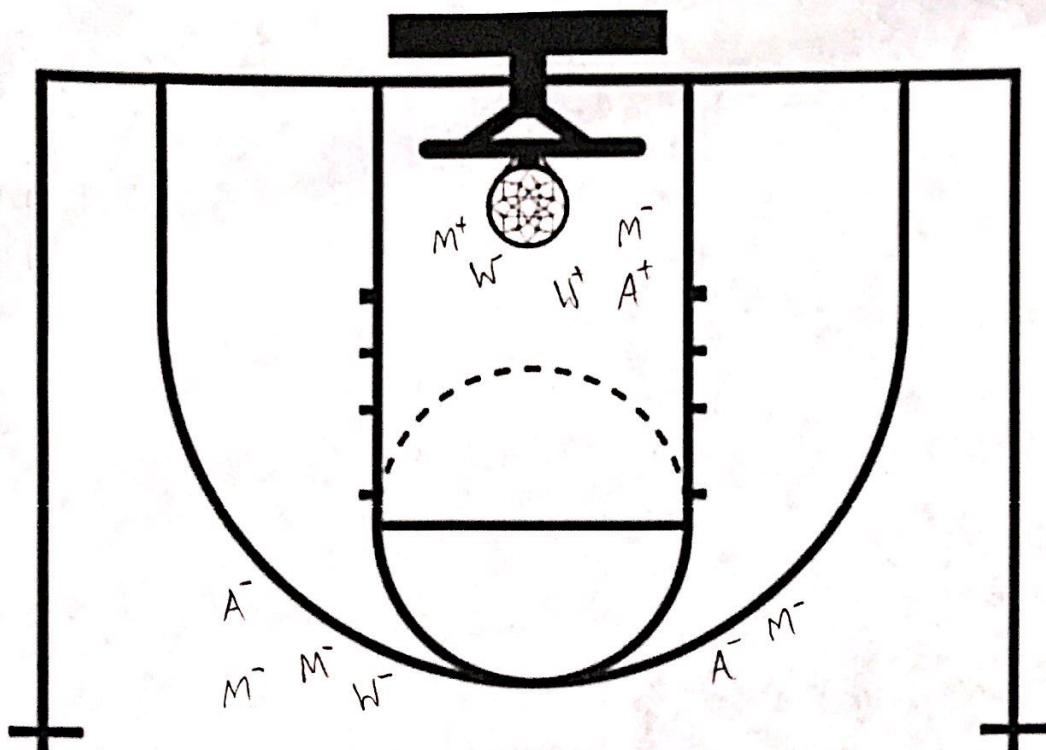






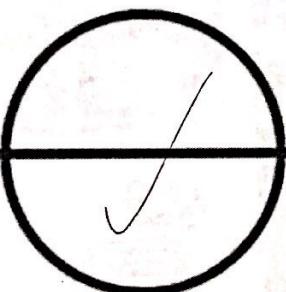






Needs
Inputting

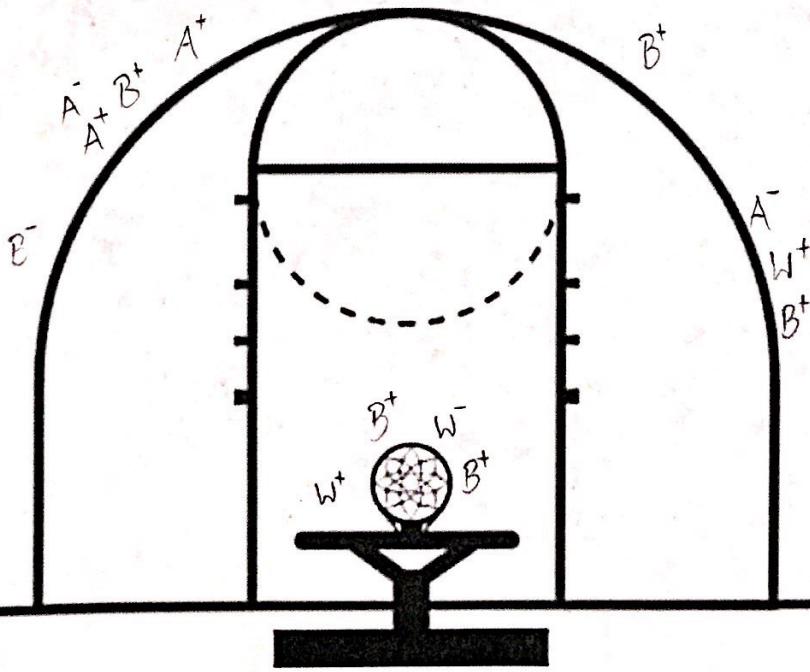
New

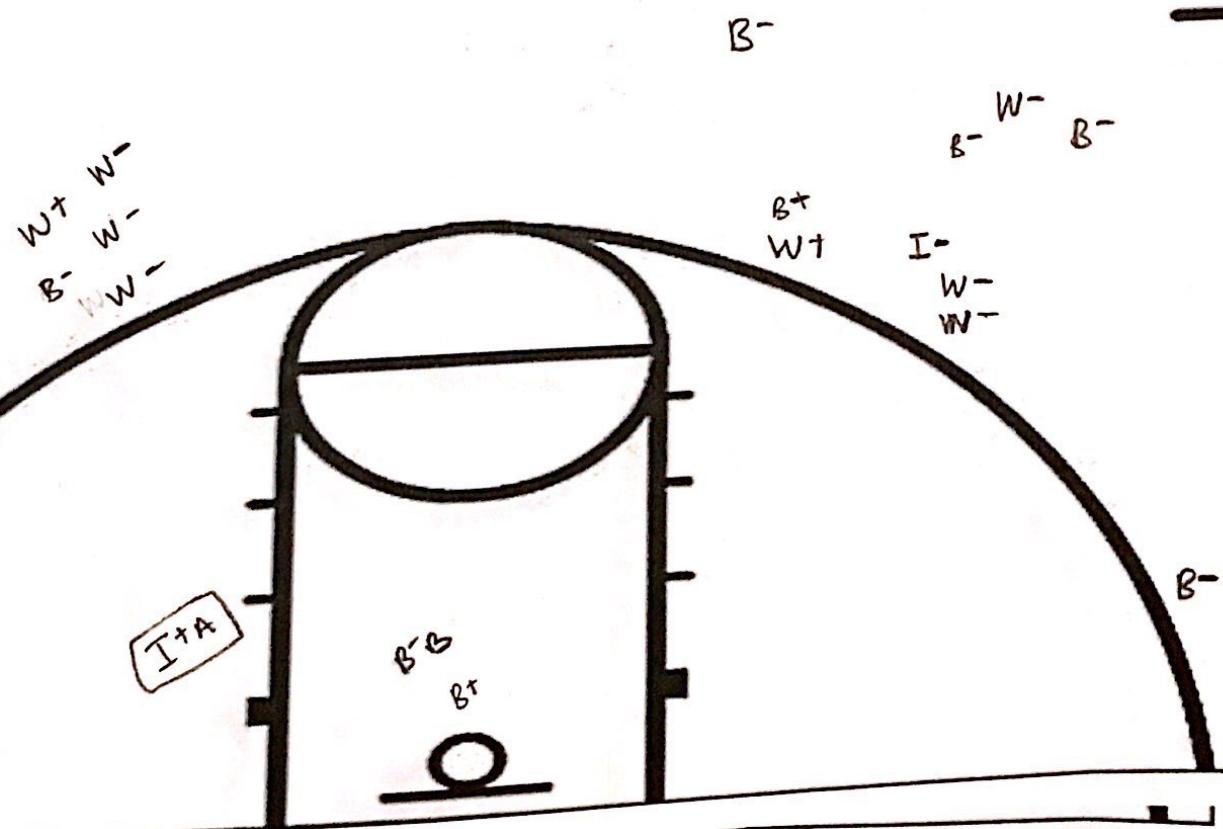
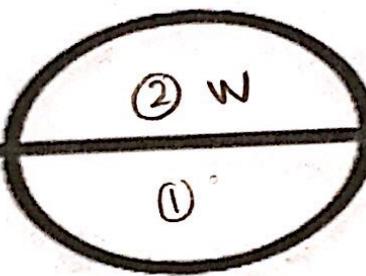
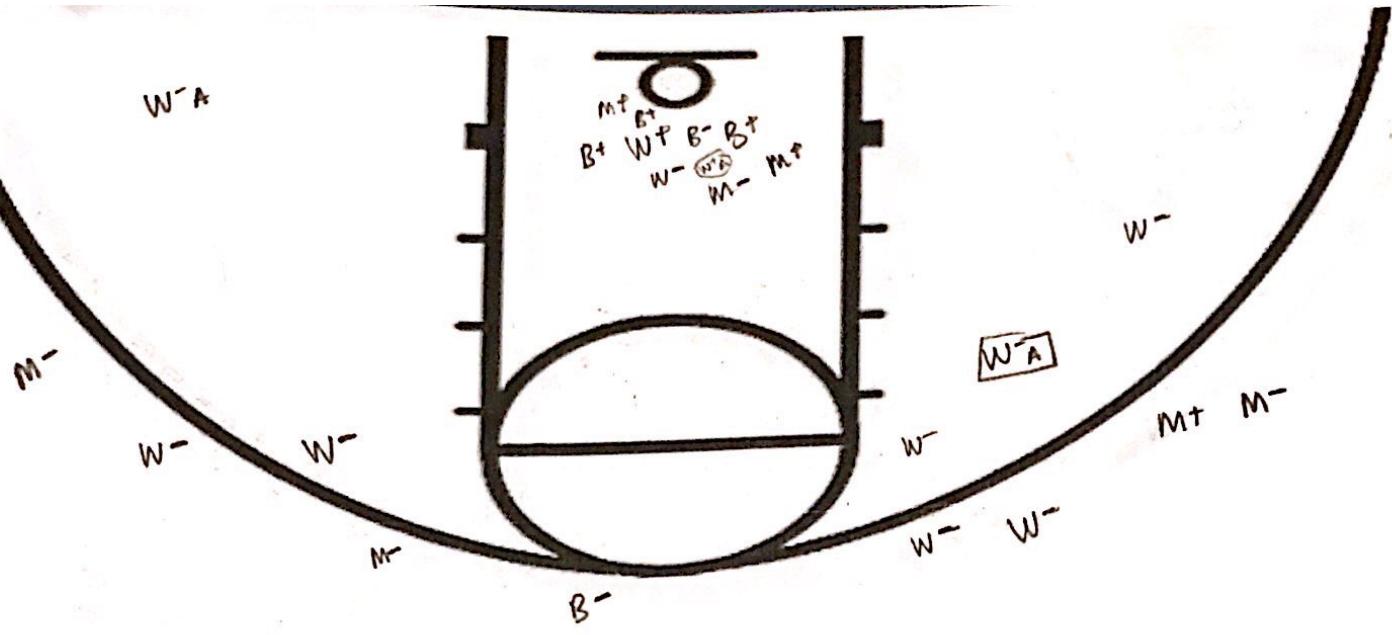


Maroon
(Consider 2 Bay?)

Win

YouthHoops101.com





2nd court

