Calculus in Cricket

Apurv Patel ID: 202301230
Harsh Patel ID: 202301192
Faran Gori ID: 202301209
Shivam Ramoliya ID: 202301049
Nauman Shethwala ID: 202301237
Jenish Macwan ID: 202301172

November 2023

1 INTRODUCTION OF CRICKET

There is no need to Introduce the Cricket to anyone.

Figure 1: Drawing of Cricket[27]

Everyone knows about cricket nowadays. Cricket was firstly introduced in the 16th century in South-East England, till now cricket is a very popular game in the world.
There is the biggest fanbase of cricket all over the world. many leagues and Tournaments of cricket are Organized all over the world by many countries.
As you know every games has some rules and regulations cricket also has many rules.
Cricket is a bat-ball game. which involves two teams and every team has 11 players. The objective of the game is to run more than opposite team. Batsman can be out by various methods like stump, runout,

bowled, LBW, catch, etc. Cricket has many formats of games like 20-20,50 Over, Test Match, One Day Match. Every match has two innings. One Team Will be bating and the other one will be fielding, It Will Be decided by Toss. In the Cricket has an umpire who makes the final decision.

2 RAIN: THE REAL PROBLEM OF THE CRICKET.

Players are playing the cricket in an open stadium.
So, there are many chances of matches getting affected by the rain often in the monsoon season.
Rain poses a persistent and frustrating challenge for cricket.
Matches can be interrupted, delayed, or even abandoned due to the unpredictability of the weather.

Figure 2: Rain Problem in Matches[33]

Figure 3: Rain in Stadium[18]

This, in turn, can be unfair for some teams.
The introduction of technology, such as weather forecasting and advanced drainage.

The use of the DLS method, although an attempt to provide fair outcomes in rain-affected matches.

From a logistical perspective, rain interruptions can complicate tournament schedules and create a domino effect of rescheduled matches, impacting the overall flow of competitions.

3 INTRODUCTION TO DLS(Duckworth-Lewis-Stern) METHOD

[48, 39, 4]

Figure 4: Match Abandoned in Matches[34]

Due to rain interruptions in limited over format Sometimes the Team Batting second may not get full overs to play and so they need not to score the full target in overs allotted to them.

Also Due to interruption Matches had to be drawn when a reserved day was used. It was not likely to favor a draw in Knockout Matches.
So now this has become a problem how

Figure 5: Frank Duckworth and Tony Lewis[21]

Figure 6: Steven Stern[22]

much will the target as Due to rain interruptions in limited over format Sometimes the Team Batting second may score for them to score.
So, Later Two English Statisticians, Frank Duckworth and Tony Lewis introduced a method i.e. formally known as the Duckworth-Lewis (D/L) method.

It was first introduced in 1997 and later in 1999 it was accepted and adopted by ICC.

After the retirement of Duckworth and Lewis, Steven Stern became the Custodian of The Method and the method was given the current name i.e. DLS(Duckworth-Lewis-Stern) Method.
The Target Score for the team batting second in Cricket Matches Without Any interruption is one more than the run scored by the team batting first.
But Sometimes due to rain interruptions overs may be decreased so the runs to be scored must be less than that to be scored in whole 50 or 20 overs.

When overs are lost, setting an adjusted target for the team batting second is not as simple as reducing the run target proportionally to the

loss in overs, because a team with ten wickets in hand and 25 or 10 overs to bat can play more aggressively than if they had ten wickets and a full 50/20 overs.
For example, and can consequently achieve a higher run rate.
The DLS Method statically attempts to set a target score for a team playing the second inning, which is just as difficult as a full-over match i.e.50 or 20 over. Any Team has two resources to score the target viz. wickets and overs for playing.
The DLS Method sets the target using these two resources.

4 STORY BEHIND CREATION

[48] Before the DLS method was introduced, various other methods were used to calculate the target score for a team batting second.
Some of the most used are the Average Run Rate(ARR) method and the Most Productive Overs(MPO) method.[7, 1]

4.1 Average Runrate Method

Figure 7: Drawing of Cricket[23]

[46] While these methods are simple and inconvenient and unsatisfying many times.
The ARR does not take account of wicket loss and only considers the scoring rate of a team batting second.
If they feel rain stoppage and over are decreased and wickets are not considered they likely score at a high run rate without likely to lose of wicket. It was used during the '50s and '60s.
if rain-interrupted matches the target for the team batting second is

given by...

$$T2 = (arr1 \times Y2) + 1 \tag{1}$$

$$T2 = (X1 \times Y2)/U1 + 1 \tag{2}$$

$$arr1 = X1/U1 \tag{3}$$

Where, T2 = New target for team 2
arr1 = Team 1's average Run Rate
Y2= Available Overs to Team 2
X1= Team 1 Total Score
U1= Overs used by Team 1

4.2 Example Of Arr:

Team 1 scored 200 runs in 50 overs match with 4 Wickets lose thus run rate of Team 1 is arr1=200/50=4 And time limitation team have 30 overs in hand to play with 10 wickets at start of second innings. New revised target for Team 2 is...

$$T2 = (arr1 \times Y2) + 1 \tag{4}$$

$$=(4*30)+1$$

$$=121$$

4.3 Example 2:

The Average Run Rate method was replaced in 1991 by the Most Productive Overs method, having been developed by Australia after the third 1989 Australian Tri-Series final between Australia and the West Indies.

Chasing Australia's 226/4 off 38 overs, the West Indies initially needed 180 off 31.2 overs (a required Run Rate of 5.74).
When rain interrupted play for 85 minutes. Under the average run-rate method, the revised target was 108, meaning the West Indies needed 61 off the 11.2 overs that remained (a required Run Rate of 5.38).
After the West Indies won the match (and the competition) by eight wickets with 4.4 overs remaining, Australian fans loudly booed this unsatisfactory conclusion, which was criticized by the media and Australia's captain Allan Border.

4.4 Most Productive Overs Method

[47]

Another method The Most Productive Overs method not only took no account of wickets lost by the team batting second, but also not considering the team batting second for good bowling by ignoring their best overs in setting the new target.

The target for Team 2 from a total of their X over = Run Scored By Team 1 in their highest scoring X overs+1.

The D|L Method was developed by Two American Statistician Frank Duckworth And Tony Lewis As A result Of Outcomes of the Semi-final of 1992 ODI World Cup Between South Africa And England.
Where South Africa Need 24 runs in 13 balls but due to rain interrupted match for 12 min.

Figure 9: England Vs South Africa[35]

And after it when match continues, As a result of Most Productive Over Method South Africa needs 21 Runs of 1 ball, reduction of 2 run as reduction of 12 balls. It's a virtually an impossible.

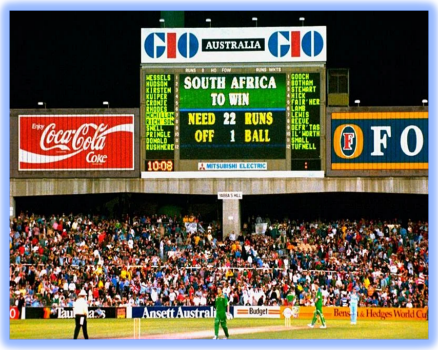


Figure 8: Score Board[25, 11]

Duckworth said, "I recall hearing Christopher Martin-Jenkins on radio saying 'surely someone, somewhere could come up with something better' and I soon realised that it was a mathematical problem that required a mathematical solution."
While using the D/L Method in this Match, South Africa needs Four Runs To tie and 5 to win in the final ball
The D/L method was first used in International Cricket on 1st January 1997 during 2nd Match of Zimbabwe vs England ODI series in which Zimbabwe won by the 7 runs.[48, 42]

Later in 1999 ICC adopt the D/L method as a standard method for

calculating the target score in rain delayed matches.

5 THE D/L Model : CALCULATION METHOD

[48, 42]

The D/L method has been of two versions.
The first was adopted by the ICC in 1997 and is mentioned in book Duckworth and Lewis (1998).

The second version, known as the Professional version, was introduced in 2003 (see Book Duckworth and Lewis, 2004) so that the method produced fairest adjustment in targets in high scoring interrupted games.

The necessities of the D/L method and Each team has these 'resources' to use to score as many runs as possible.

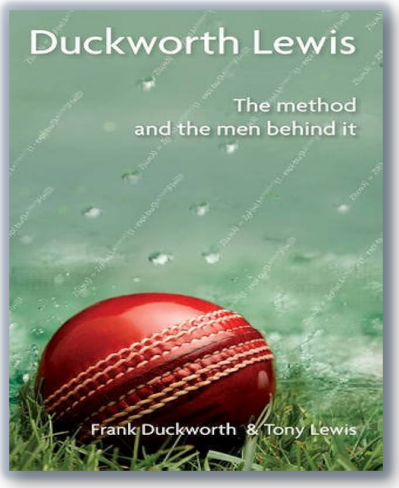


Figure 10: The DLS Book[28]

The number of overs they have to play and the number of wickets they have not lost i.e. they have in their hand.
At any time during any inning, a team's possibility to score more runs are depends on the combination of these two resources they have left.
Looking at the scores, there is a very close correspondence between the availability of these resources and a team's final score.
The D/L method converts all possible combinations of overs (or, more accurately, balls) and wickets left into a remaining percentage figure (with 50 overs

and 10 wicket table).

The target score for the team batting second (Team 2) can be adjusted more or less from the total of the team batting first (Team 1) are calculated using these resource percentages, to reflect the loss of resources to one or both teams when a match is shortened once or more.

This Version of D/L Method was commonly used in first class cricket (i.e. Professional Cricket), in which target score for team 2 is calculated as a proportion of two team's resources.

$$Team2'sParTotalScore = Team1'sScore \times Team2'sResources/Team1'sResources \tag{5}$$

It usually occurs that this 'par score' is a non-integer number of runs. Then Team 2's target to win is a number rounded up to the next integer, and the score to tie (also called the par score), is a number rounded down to the preceding integer i.e. number just before it.

If Team 2 manage to reaches or passes the target score, then they have won the match.

If the match ends when Team 2 manage to exactly met (but not passed) the par score, then the match is given a tie.

If Team 2 fail to reach the par score, then they have lost.

5.1 Example:

For example, if a rain delay means that Team 2 only has 90% of resources available, and Team 1 scored 254 with 100% of resources available.

Then, 254 × 90% / 100% = 228.6

So Team 2's target is 229, and the score to tie is 228.

The actual resource values used in the Professional Edition are publicly unavailable, so a computer that has this software loaded must be used. If it is a 50-over match and Team 1 completed its innings uninterrupted. Then they had 100% resource available to them, so the formula simplifies to:

Team 2's Par Score = Team 1 total score * Team 2's Available resource

6 MATHEMATICAL THEORY

[48, 41, 38, 37]

6.1 For 20' Overs

	20 Overs		**50 Overs**	
	$\mathbf{Z_0}$	**b(w)**	$\mathbf{Z_0}$	**b(w)**
0	236.836	0.027	150.08	0.027
1	210.822	0.031	132.772	0.031
2	180.629	0.036	114.091	0.036
3	148.989	0.044	94.607	0.043
4	118.046	0.055	75.012	0.055
5	88.992	0.073	56.309	0.073
6	62.019	0.105	39.325	0.105
7	38.874	0.167	24.61	0.168
8	21.082	0.308	13.34	0.31
9	8.301	0.759	5.26	0.764

How to Calculate the table

$$Z = Z(u, w) = Z_0(1 - e^{-b(w)u}) \tag{6}$$

$$P(u, w) = Z(u, w)/Z(u = 20, w = 0) \tag{7}$$

Now for 1 cell in the table.....
It's clearly 100% because we have 100% resources because no over left.

Overs Available	0	1	2	3	4	5	6	7	8	9	10
20	100	96.8	92.6	86.7	78.8	68.2	54.4	37.5	21.3	8.3	0
19	96.1	93.3	89.2	83.9	76.7	66.6	53.5	37.3	21	8.3	0
18	92.2	89.6	85.9	81.1	74.2	65	52.7	36.9	21	8.3	0
17	88.2	85.7	82.5	77.9	71.7	63.3	51.6	36.6	21	8.3	0
16	84.1	81.8	79	74.7	69.1	61.3	50.4	36.2	20.8	8.3	0
15	79.9	77.9	75.3	71.6	66.4	59.2	49.1	35.7	20.8	8.3	0
14	75.4	73.7	71.4	68	63.4	56.9	47.7	35.2	20.8	8.3	0
13	71	69.4	67.3	64.5	60.4	54.4	46.1	34.5	20.7	8.3	0
12	66.4	65	63.3	60.6	57.1	51.9	44.3	33.6	20.5	8.3	0
11	61.7	60.4	59	56.7	53.7	49.1	42.4	32.7	20.3	8.3	0
10	56.7	55.8	54.4	52.7	50	46.1	40.3	31.6	20.1	8.3	0
9	51.8	51.1	49.8	48.4	46.1	42.8	37.8	30.2	19.8	8.3	0
8	46.6	45.9	45.1	43.8	42	39.4	35.2	28.6	19.3	8.3	0
7	41.3	40.8	40.1	39.2	37.8	35.5	32.2	26.9	18.6	8.3	0
6	35.9	35.5	35	34.3	33.2	31.4	29	24.6	17.8	8.1	0
5	30.4	30	29.7	29.2	28.4	27.2	25.3	22.1	16.6	8.1	0
4	24.6	24.4	24.2	23.9	23.3	22.4	21.2	18.9	14.8	8	0
3	18.7	18.6	18.4	18.2	18	17.5	16.8	15.4	12.7	7.4	0
2	12.7	12.5	12.5	12.4	12.4	12	11.7	11	9.7	6.5	0
1	6.4	6.4	6.4	6.4	6.4	6.2	6.2	6	5.7	4.4	0

For u=0,
It means that no over left to bat with the help formula we can easily count value Z=0, which is represent at bottom at table.

6.1.1 Example 1:

First we have to calculate Z(u=20, w=0) with (6) equation calculate.

$$Z(u=20,w=0) = 236.838\ (1- e\text{-}0.027*20).$$
$$= 98.82$$

After that we have to find Z(u=19, w=0)

Z(u=19, w=0)=95.04
P(u=19, w=0)= Z(u=19,w=0)/Z(u=20,w=0)
=96.11

For 20 over first if 1 over reduces then resources will be equal to

$$P=96.11$$

Now
Which occupy the second cell of the table in T20 table.

6.1.2 Example 2:

If 10 over remaining and wicket lost is 4 then the resources,

$$Z(u=20,w=0)=236.838\ (1- e\text{-}0.027*20)=98.82$$
$$Z(u=10,w=4)= 236.838\ (1- e\text{-}0.027*19)=49.93$$
$$P(u=10,w=0)=Z(u=10,w=4)/Z(u=20,w=0)$$
$$=49.93/98.82$$
$$=50\%$$

Now
Which occupy the cell which ROW is 10 and COLUMN is 4.

6.1.3 Example 3:

If 15 over remaining and wicket lost is 2 then the resources,
Z(u=15, w=2) will be

$$Z(u=20,w=0)=236.838\ (1\text{-}e\text{-}0.027*20)=98.82$$
$$Z(u=15,w=2)=\ 180.629\ (1\text{-}\ e\text{-}0.036*15)==74.41$$
$$P(u=15,w=2)=Z(u=15,w=2)/Z(u=20,w=0)$$
$$=74.1/98.82$$
$$=75.31\%$$

Now
Which occupy the cell which ROW is 15 and COLUMN is 2 in the table.

6.1.4 Example 4:

If 15 over left to play and 7 wicket lost then the resources,
Z(u=15, w=7) will be

$$Z(u=20,w=0)=236.838\ (1\text{-}\ e\text{-}0.027*20)=98.82$$
$$Z(u=5,w=7)=\ 38.874\ (1\text{-}\ e\text{-}0.167*5)=22.007$$
$$P(u=5,w=7)=Z(u=5,w=7)/Z(u=20,w=0)$$
$$=22.007/98.82$$
$$=22\%$$

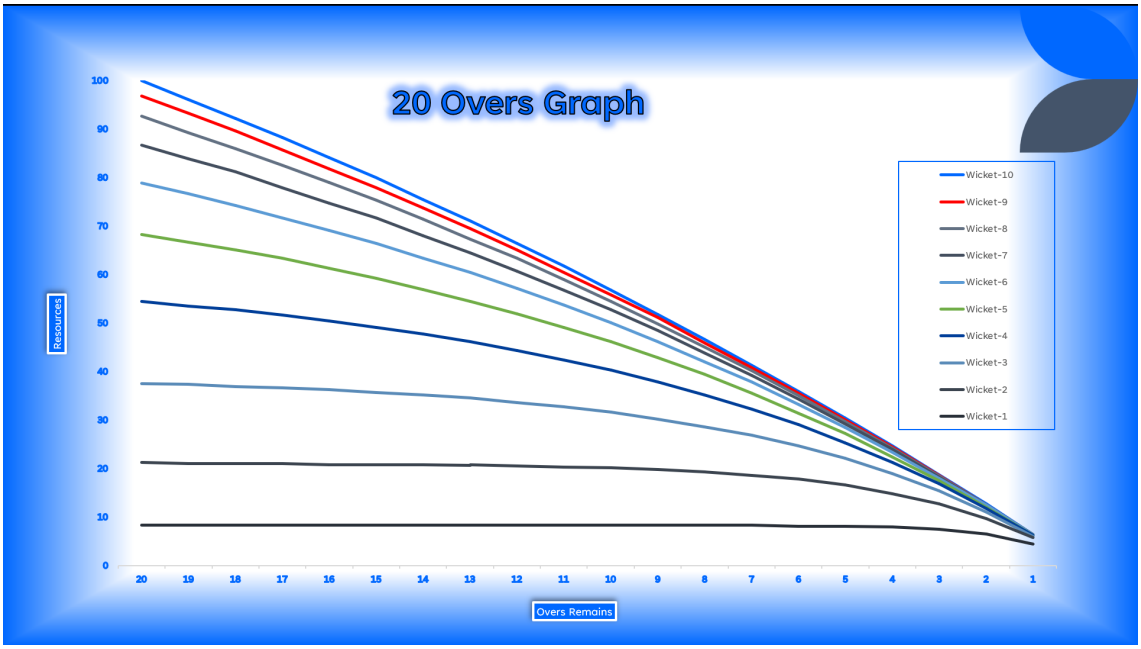
Now
Which occupy the cell which ROW is 5 and COLUMN is 7 in the table.

6.1.5 Example 5:

If 1 over remaining and wicket lost is 9 then the resources,

$$Z(u=20,w=0)=236.838\ (1-\ e\text{-}0.027*20)=98.82$$
$$Z(u=1,w=9)=\ 8.301\ (1-\ e\text{-}0.759*1)=49.93$$
$$P(u=1,w=9)=Z(u=1,w=9)/Z(u=20,w=0)$$
$$=49.93/98.82$$
$$=50\%$$

6.2 Graph For 20 Over



Now
Which occupy the cell which ROW is 1 and COLUMN is 9.

6.3 For 50' Overs

For ODI (One Day International):

6.3.1 Example 1:

First Calculate Z(u=50, w=0) which is equal to 111.17

$$Z(u=50, w=0) = 111.17$$
$$Z(u=49, w=0) = 110.1$$
$$P=99.1$$

As we calculated above.
Which occupy the second cell of the table in the 50 over table.

6.3.2 Example 2:

If 5 over left to play and all wickets are in hand then for the resources, Z(u=35, w=0) will be

$$Z(u=35, w=0)=91.74$$
$$P(u=35, w=0)=82.5$$

Which occupy the cell which ROW is 35 and COLUMN is 0 in the table.

Overs Left	0	1	2	3	4	5	6	7	8	9	10
50	100	93.4	85.1	74.9	62.7	49	34.9	22	11.9	4.7	0
49	99.1	92.6	84.5	74.4	62.5	48.9	34.9	22	11.9	4.7	0
48	98.1	91.7	83.8	74	62.2	48.8	34.9	22	11.9	4.7	0
47	97.1	90.9	83.2	73.5	61.9	48.6	34.9	22	11.9	4.7	0
46	96.1	90	82.5	73	61.6	48.5	34.8	22	11.9	4.7	0
45	95	89.1	81.8	72.5	61.3	48.4	34.8	22	11.9	4.7	0
44	93.9	88.2	81	72	61	48.3	34.8	22	11.9	4.7	0
43	92.8	87.3	80.3	71.4	60.7	48.1	34.7	22	11.9	4.7	0
42	91.7	86.3	79.5	70.9	60.3	47.9	34.7	22	11.9	4.7	0
41	90.5	85.3	78.7	70.3	59.9	47.8	34.6	22	11.9	4.7	0
40	89.3	84.2	77.8	69.6	59.5	47.6	34.6	22	11.9	4.7	0
39	88	83.1	76.9	69	59.1	47.4	34.5	22	11.9	4.7	0
38	86.7	82	76	68.3	58.7	47.1	34.5	21.9	11.9	4.7	0
37	85.4	80.9	75	67.6	58.2	46.9	34.4	21.9	11.9	4.7	0
36	84.1	79.7	74.1	66.8	57.7	46.6	34.3	21.9	11.9	4.7	0
35	82.7	78.5	73	66	57.2	46.4	34.2	21.9	11.9	4.7	0
34	81.3	77.2	72	65.2	56.6	46.1	34.1	21.9	11.9	4.7	0
33	79.8	75.9	70.9	64.4	56	45.8	34	21.9	11.9	4.7	0
32	78.3	74.6	69.7	63.5	55.4	45.4	33.9	21.9	11.9	4.7	0
31	76.7	73.2	68.6	62.5	54.8	45.1	33.7	21.9	11.9	4.7	0
30	75.1	71.8	67.3	61.6	54.1	44.7	33.6	21.8	11.9	4.7	0
29	73.5	70.3	66.1	60.5	53.4	44.2	33.4	21.8	11.9	4.7	0
28	71.8	68.8	64.8	59.5	52.6	43.8	33.2	21.8	11.9	4.7	0
27	70.1	67.2	63.4	58.4	51.8	43.3	33	21.7	11.9	4.7	0
26	68.3	65.6	62	57.2	50.9	42.8	32.8	21.7	11.9	4.7	0
25	66.5	63.9	60.5	56	50	42.2	32.6	21.6	11.9	4.7	0
24	64.6	62.2	59	54.7	49	41.6	32.3	21.6	11.9	4.7	0
23	62.7	60.4	57.4	53.4	48	40.9	32	21.5	11.9	4.7	0
22	60.7	58.6	55.8	52	47	40.2	31.6	21.4	11.9	4.7	0
21	58.7	56.7	54.1	50.6	45.8	39.4	31.2	21.3	11.9	4.7	0
20	56.6	54.8	52.4	49.1	44.6	38.6	30.8	21.2	11.9	4.7	0
19	54.4	52.8	50.5	47.5	43.4	37.7	30.3	21.1	11.9	4.7	0
18	52.2	50.7	48.6	45.9	42	36.8	29.8	20.9	11.9	4.7	0
17	49.9	48.5	46.7	44.1	40.6	35.8	29.2	20.7	11.9	4.7	0
16	47.6	46.3	44.7	42.3	39.1	34.7	28.5	20.5	11.8	4.7	0
15	45.2	44.1	42.6	40.5	37.6	33.5	27.8	20.2	11.8	4.7	0
14	42.7	41.7	40.4	38.5	35.9	32.2	27	19.9	11.8	4.7	0
13	40.2	39.3	38.1	36.5	34.2	30.8	26.1	19.5	11.7	4.7	0
12	37.6	36.8	35.8	34.3	32.3	29.4	25.1	19	11.6	4.7	0
11	34.9	34.2	33.4	32.1	30.4	27.8	24	18.5	11.5	4.7	0
10	32.1	31.6	30.8	29.8	28.3	26.1	22.8	17.9	11.4	4.7	0
9	29.3	28.9	28.2	27.4	26.1	24.2	21.4	17.1	11.2	4.7	0
8	26.4	26	25.5	24.8	23.8	22.3	19.9	16.2	10.9	4.7	0
7	23.4	23.1	22.7	22.2	21.4	20.1	18.2	15.2	10.5	4.7	0
6	20.3	20.1	19.8	19.4	18.8	17.8	16.4	13.9	10.1	4.6	0
5	17.2	17	16.8	16.5	16.1	15.4	14.3	12.5	9.4	4.6	0
4	13.9	13.8	13.7	13.5	13.2	12.7	12	10.7	8.4	4.5	0
3	10.6	10.5	10.4	10.3	10.2	9.9	9.5	8.7	7.2	4.2	0
2	7.2	7.1	7.1	7	7	6.8	6.6	6.2	5.5	3.7	0
1	3.6	3.6	3.6	3.6	3.6	3.5	3.5	3.4	3.2	2.5	0
0	0	0	0	0	0	0	0	0	0	0	0

6.3.3 Example 3:

If 28 over left to play and 1 wicket lost then for the resources, Z(u=28, w=1) will be

$$Z(u=28, w=1)=76.71$$
$$P(u=28, w=1)=68.8$$

Which occupy the cell which ROW is 28 and COLUMN is 1 in the table.

6.3.4 Example 4:

If 20 over left to play and 5 wicket lost then for the resources, Z(u=20, w=5) will be

$$Z(u=20, w=5)=43.23$$
$$P(u=20, w=5)=38.6$$

Which occupy the cell which ROW is 20 and COLUMN is 5 in the table.

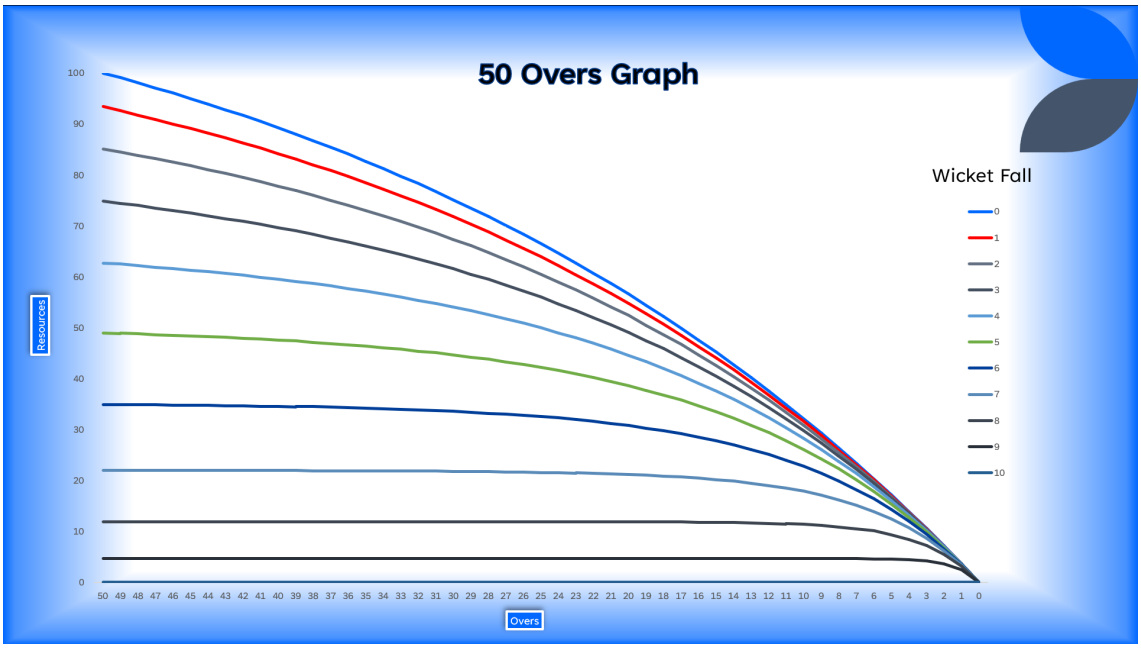
6.3.5 Example 5:

If 5 over left to play and 6 wicket lost then for the resources, Z(u=5, w=6) will be

$$Z(u=5,\ w=6)=16.06$$
$$P(u=5,\ w=6)=14.3$$

Which occupy the cell which ROW is 5 and COLUMN is 6 in the table.

6.4 Graph For 50 Over



7 SOME CASES OF STOPPAGE IN MATCHES

[48]

7.1 Increase in Target.

In fourth ODI of India-England in 2008 ODI Series 1st inning was interrupted twice and as result both innings are reduced to 22 overs.

7.1.1 Example 1:

While batting first India scored 166/4 and target for England was set to 198 in 22 overs.
England was expected to chase the score in 22 overs as compared to India who scored 166 in their interrupted inning, but England made 178/8 in 22 overs and India is declared winner by the 19 runs and listed as "India won By 19 Run (D|L Method)".

Figure 11: India Vs England[31]

[8]

7.1.2 Example 2:

During the fifth ODI series of India-South Africa in 2011, rain halted the 1st inning and as a result the overs are reduced to 46 in both the innings.

Africa scores 250/9 in their 46 overs and as a result of D|L method the target for India was set to 268 as the match was interrupted during the south Africa's inning so as they does not know about it from the start of the inning and as the result South Africa was declared as winner by 33 runs and listed as "South Africa Won By 33 Runs (D|L Method)"

Figure 12: India Vs South Africa[29]

[13]

r0.4 

Figure 13: India Vs Pakistan[36]
[43]

7.2 Stoppage in Second Inning.

7.2.1 Example: 1

A another example of the D/L method used was in the first ODI between India and Pakistan in their 2006 ODI series.
India batted first, and were all outed for 328. Pakistan batting second, were on 311/7 when bad light stopped play after the 47th over.
Pakistan's target when the match continued, was 18 runs needed in 18 balls, with three wickets in their hand.
Considering the run rate throughout the match, this target, most teams would be favoured to achieve. And indeed, application of the D/L method resulted in a target score of 305 (or par score of 304) at the end of the 47th over, with the result therefore listed as "Pakistan won by 7 runs (D/L Method)".

7.2.2 Example: 2

The D/L method was also used in the group stage match between Sri Lanka and Zimbabwe at the T20 World Cup in 2010.
Sri Lanka while batting first scored 173/7 in 20 overs, and in second inning Zimbabwe was at 4/0 from 1 over when rain interrupted play.

Figure 14: Sri Lanka Vs Zimbabwe[30] [15]

When the Match restart Zimbabwe's target was reduced to 108 in Just 12 overs, but again rain stopped the match when they had scored 29/1 from 5 overs.
The D/L target from 5 overs was a further reduction to 44, and a par score of 43, and as a result Sri Lanka won the match by 14 runs.

7.2.3 Example: 3

The DLS method was also used after the rain disruption in the 2023 Indian Premier League final.[5] Where Chennai Super Kings had scored 4/0 (0.3 overs) and the Gujarat Titans just scored 214/4 (20 overs).
The target was reduced to 171 runs in 15 overs from previous target 215 runs from

Figure 15: GT Vs CSK[24]

r0.4 

Figure 16: India Vs England[17]

20 overs for Chennai Super Kings. Chennai Super Kings won by 5 wickets by the DLS method.[9]

7.2.4 Example: 4

An example of a D/L tied match was the ODI between England and India, played on 11 September 2011.

This match was frequently interrupted by rain in the last overs, and a ball-by-ball calculation of the Duckworth–Lewis 'par' score played a key role in crucial decisions during those overs.

At one point, India were leading under D/L during one rain delay, and would won if play does not resume.

At a second rain interval, England, who had scored some quick runs (knowing they needed to get ahead in D/L terms) would have correspondingly won if play does not resume.
Play was resumed with just 7 balls of the match remaining and England's score just equal to the Duckworth–Lewis 'par' score and therefore resulting is declared as tie.
This example shows how crucial and difficult the umpire's decision can be, in assessing when rain is heavy enough to justify ceasing play.
If the umpires had halted play one ball earlier, England would have been ahead on D/L, and so would have won the match.
Same as, if play stopped one ball later, India Would won the match with a dot balls – indicating how finely-tuned D/L Method calculations can be in such situations.

7.3 Stoppage in Both Innings.

During the 2012-13 KFC Big Bash League, D/L was used in the 2nd semi-final which was played between the Melbourne Stars and the Perth Scorchers.

After rain delayed the start of the match, it interrupted Melbourne's innings when they had scored 159/1 in 15.2 overs, and both innings were reduced by 2 overs to 18, and Melbourne finished at 183/2.

After a further rain delay reduces Perth's innings to 17 overs, As Perth returned to the field, a revised target was 139 off 13 Overs.

Figure 17: Melbourne Stars Vs Perth Scorchers[?]

[12]

Perth won the game by 8 wickets with a
boundary on the final ball.

8 USES AND UPDATES

[48, 45, 3, 2, 6]

The table of D/L method is regularly updated [certification needed]* using analyzed data of the recent matches, every year this is done on 1 July.

As decided by D/L, for 50 overs matches each team must at least play 20 overs for valid result, and for 20 overs each team must play 5 overs, unless one or both are all out or second chased in lesser overs.

If the above mentioned conditions are not satisfied, then result will declare as draw or no result.

8.1 1996-2003, Single edition

The single edition of D/L was used till 2003.

This uses the single published reference table of total resource and percentages remaining for all possible combinations of wickets and overs, and some other simple mathematical calculations, and was relatively transparent and straightforward to implement.

However, a flaw in how it handled very high scores (350+) in first innings became apparent from the 1999 Cricket World Cup match in Bristol which played between India and Kenya.

Tony Lewis noticed that there was an inherent weakness in the equation that would give an advantage to the team chasing a total which exceeds 350.

A correction was done into the equation and the software, but was not adopted until 2004.

ODI matches now were achieving significantly high scores than in the previous decades, affiliating the historical relationship between resources and runs.
The second version/edition uses more sophisticated statistical modelling, but does not use a single table of resource percentages.
Instead, the percentages also vary with score, so a computer is required to store the Data and Calculations.
Therefore, it loses it's some of the previous advantages of simplicity and transparency.

In 2002 the resource percentages were redevised, following an extensive analysis of limited overs matches, and there was a change to the G50 for ODIs.
G50 is the average score expected from the team batting first in an uninterrupted 50 overs-per-innings matches or say ODI matches.
G50 was changed to 235 for ODIs.

G50 Value table over periods of time.

Time Duration	Matches involving ICC full member nations	Matches between team that plays first class matches	Under-19 internationals	Under-15 Internationals	Matches between ICC associate member nations	Women's ODIs
1999-31 August 2002	225	Yet not decided				
1 September 2002-2006	235					
2006/07	235			200	190	175
2007/08						
2008/09						
2009/10	245		200			
2010/11						
2011/12						
2012/13						
2013-Till date						

These changes came into effect on September 1st, 2002.
As of 2014, these resource percentages are the ones still in use in the Standard Edition, though G50 has been subsequently changed.

The table below shows the changes done in resource percentage in 2002 with that of used in 1999 to 2001 –

8.2 2004 – Adoption of second version

The original version was known as the Standard Edition, and the new version was known as the Professional Edition.
Tony Lewis said, "We were then [at the time of the 2003 World Cup Final] using what is now known as the Standard Edition. ... Australia got 359 and that showed up the flaws and straight away the next edition was introduced which handled high scores much better. The par score for India is likely to be much higher now."
Duckworth and Lewis wrote, "When the side batting first score at or below the average for top level cricket ..., the results of applying the Professional Edition are generally similar to those from the Standard Edition. For higher scoring matches, the results start to diverge and the difference increases the higher the first innings total. In effect there is now a different table of resource percentages for every total score in the Team 1 innings."
The Professional Edition has been implemented in use in all international ODI cricket matches since early 2004. This edition also removes the uses of the G50 constants when dealing with any of interruptions in the first innings.
The decision on which this edition should be used is only for the cricket authorities that runs the particular tournaments.
The ICC Playing Handbook requires the use of the Professional Edition for international tournaments.

This also applies to most of countries' national competitions like India's Indian Premier League (IPL), Australia's Big Bass League and soon... At lower levels of the game, where use of a computer or say professional edition cannot always be guaranteed to used, the Standard Edition may be used.

8.3 Twenty20 Updates

In June 2009, it was reported that the D/L method would also be reviewed for the T20 format after its all the appropriateness was questioned in the quickest format of the games.
Tony Lewis was quoted admitting that "Certainly, people have suggested that we need to look very carefully and see whether in fact the numbers in our formula are totally appropriate for the Twenty20 game."

8.4 2015-Becomes DLS

For the 2015 World Cup, the ICC implemented the Duckworth–Lewis–Stern(DLS) formula, which also included work done by the new custodian of the method.
Professor Steven Stern, from the Department of Statistics at Queensland University of Technology.
These changes recognised that teams need to start with a higher run rate when chasing high targets rather than to keep wickets in hand.

9 IMPACT ON TEAM 2'S TARGET:

[48]

If rain interrupted matches before start of the first innings then numbers of reduce for both teams are same so D/L method makes no change to team 2's target, because both teams are aware of the total numbers of overs for playing and wickets in hand throughout their innings, thus before the match start both teams resources are same.
Team 2's new target is first calculated after the team 1's innings has finished.

If rain interrupted match after first inning started and overs reduces for both teams are same then new target score for team 2 will calculated using D/L method which is describe in below content.
For calculate to team 2's new target after interruption in team 1's Innings is often an increase, when team 2 has more resources available than team had.
Though both teams have same 10 wickets and same numbers of overs(reduced overs) available and also this an increase is fair because at start of the match team 1 thought that they have more overs to bat but due to rain interruption both teams overs are reduced same.
If they already known that they have less overs to bat then they play more aggressively and scored more runs.
In this case team 1 tries to save wickets in initial overs but there is no need to do such thing for team 2 because they already knows that they have less overs.
In this case the increased new target for team 2 is what D/L method thinks Team 1 would have scored in overs if they already known that they have less overs to play.

9.1 Example

If Team 1 batted for 25 overs and then rain interrupted match and after rain stopped match started and decided that both team overs reduced

to 30 overs then after first innings target score for team 2 will be greater than team 1 scored in their 30 overs using D/L method.

If there are interruption due to rain in team 2's innings, it may be before second innings starts or during second innings then using D/L method new target for team 2 will be reduced and if there are many interruptions during second innings, then each time new target calculated downwards using D/L method.
If there are many interruptions which include both increase and decrease the target for team 2, then the net effect on the target could be either increase or decrease of actual target, depending which interruptions were weighty.

10 TARGET SCORE CALCULATION.

[48]

Using the notation mentioned in ICC Playing Handbook, the team that bats first i.e. Team 1, their final score is called S, the total resources available to Team 1 for their innings is called R1, the team that bats second i.e. Team 2, and the total resources that are available to Team 2 for their innings is called R2.

10.1 Step 1. Find the batting resources available to each team

After reduction in overs, the new net total batting resources available to each teams are found, using table for the total amount of batting resources remaining for any combination of overs and wickets.
While the process of converting these total remaining resource into total available resource is the same in both the Editions, this can be done manually in the Standard Edition, as the remaining resource are published in a reference table.

However, the remaining resource used in the Professional Edition are not publicly available, so a computer must be used which has the software loaded.

If any team loses resource at the start of an innings (image below), then this is very simple.
For example, if the first 20 overs of an innings were lost, then 30 overs and 10 wickets will be remaining, i.e. 75.1% in the Standard Edition, so this are the resource which are available.

If a team loses its resource at the end of its innings (image below), then the resource that was available to that team can be found by taking the resources it had at the start of inning, and subtracting the resources remaining at the point the innings was ended.

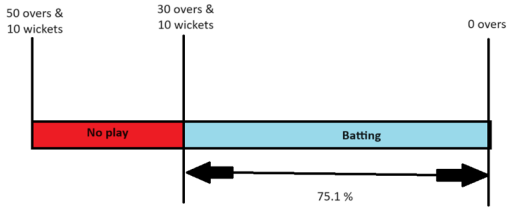


Figure 18: Visual Display1

For example, if a team starts with 50 overs and 10 wickets (100% of its resources), but its innings is ended with 20 overs and 8 wickets remaining (52.4% of its resources), then the resources actually used is 100% - 52.4% = 47.6% or say remaining resources are 52.4%.

in the Standard Edition, so this are the resource which are available.

If a team loses resource in the middle of innings (image below), then the resource that was available to the team are found by taking the resources it had at the start of the inning, and subtracting the resources remaining at the point of the innings when the inning was interrupted (to give the resources that are used in the first period of the innings), then adding on the resource that are remaining at the restart.

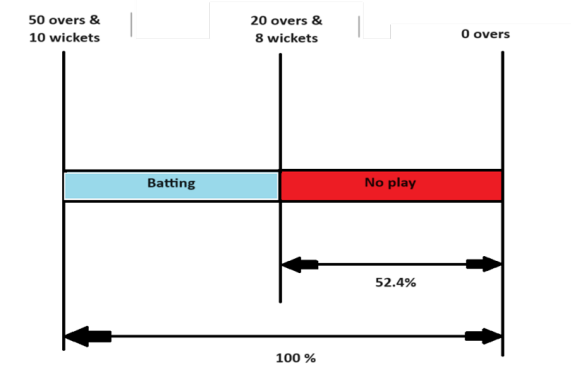


Figure 19: Visual Display2

For example, if a team at starts with 50 overs and 10 wickets in hand (100% of its resources), but is interrupted when it still has 40 overs and 8 wickets remaining (77.8% of its resources), and restarted when it has 20 overs and 8 wickets in hand (52.4% of its resources), then the resources it actually used is 100% - 77.8% + 52.4% = 74.6%.
Another way of looking at this is to say that it lost the resources available between 40 overs and 8 wickets (77.8%) and 20 overs and 8 wickets (52.4%), i.e. 77.8% - 52.4% = 25.4%, so its total resource available was 100% - 25.4% = 74.6%.

in the Standard Edition, so this are the resource which are available.

These are just the examples of different ways of having one interruption.
While with multiple interruptions are also possible, it may seem like

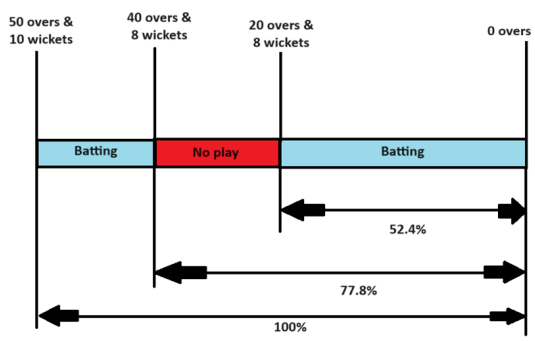


Figure 20: Visual Display3

finding the total resource percentage needs a different calculation for each different types of scenario.
However, the formula is actually the same each time - it's just that different scenarios, just with some more or less interruptions and restarts, need to use more or less of the same formula.
The total resources available to a team is given by:

Resources Remaining=100% -Resources Remaining at 1st inturreption +Resources Remaining at 1st restart -Resources Remaining at 2nd inturreption +Resources Remaining at 2nd restart...

Each time when there is an interruption or a restart after an interruption, the resource remaining percentages at those times (can be obtained from a reference table for the Standard Edition, or from a computer for the Professional Edition) can be used into the formula, with the rest left unfilled.
Rain at the start of the match causes 1st interruption.

10.2 Step 2. Calculate the resources

If R2 $<$ R1, reduce in Team 2's target score is proportion to the reduction in total resources, i.e.

$$S \times R2/R1. \tag{8}$$

If R2 = R1, no changes to Team 2's target score is done.
If R2 R1, increase in Team 2's target score by the extra runs that could

be expected to be scored on average with some extra total resource, i.e.

$$S + G50 \times (R2 - R1)/100 \tag{9}$$

, where G50 is the average 50-over total run.
Team 2's target score is not just simply increased proportionally to the increase in total resources, i.e. S × R2/R1, as this could lead to some unrealistically high target score if Team 1 had achieved an early high rate of scoring [in the powerplay overs] and rain caused a major reduction in the overs for the match.
Instead, of that D/L Standard Edition requires average performance of Team 2's additional resource over Team 1.

11 SOME EXAMPLES OF HOW TARGET SCORE WAS CALCULATED

[48]

The DLS Method has five different cases:
Case 1:-
The 01st Team Completed Bating, but at the start of the 2nd Team Bating was delayed for some reason. In This Case, Step Resources are reduced at the start of the innings.
Case 2:-
1st Team Completed Bating, but at the start of the 2nd Team Bating is curtailed because of some reason. In This Case Resources were reduced at end of the innings.
Case 3:-
1st Team Completed, but at the start of the 2nd Team is Interrupted due to some problem, at the result 2nd team over and run will be decreased According to DLS. In This Case, Resources were reduced at middle of

the innings.
Case 4:-
1st Team bating curtailed. Resources were reduced at the end of the innings.
Case 5:-
1st Team innings is interrupted in the middle. Resources were reduced at the middle of the innings.

11.1 Case 1:

On 18 May 2003 in 2003 ECB National League Lancashire played Hampshire.[10]

At that time rain stopped match before start.
Thus due to less time both team get 30 overs before match start this was decided.
In 30 overs Lancashire had made 231 run at lose of 4 wickets in first innings.

Before second innings started ran again stopped match so finally Hampshire got 28 overs to bat.

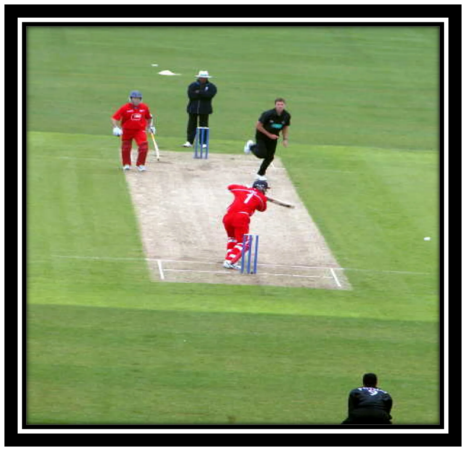


Figure 21: Lancashire Vs Hampshire[19]

11.1.1 Step 1: We Have to See on Table How Many Resources are remaining

Resources are remaining to Lancashire = R1
Resources are remaining to Hampshire = R2

[40]

Resource from table team has 30 overs remaining and the team has 10 wickets on hand.
From Resource Table R1=75.1%
After that for Second Team
Resource from table team has 28 overs remaining and the team has 10 wickets on hand.
From Resource Table R2=71.8%

11.1.2 Step 2:

Team 2's Par Total Score = Team 1's Score×Team 2's Resources/$Team1'sResources$ (10)

=231*71.8/75.1 =221 Run

In that match Hampshire all out at 150 run so Lancashire win by 220-150=70 Runs.

11.2 Case :2

There was a match between Sri Lanka and South Africa on 3 March 2003 in 2003 ICC Cricket World Cup.
In 50 overs Sri Lanka had made 268 runs at lose of 9 wickets in first innings.
In second innings South Africa scored 229 runs at lose of 6 wickets in 45 overs. After that play was stopped.

11.2.1 Step 1: Find Available Resources From Table :

Total Resources available to Sri Lanka=R1
Total Resources available to South Africa=R2

Resource from table team has 50 overs remaining and the team has 10 wickets on hand.
From Resource Table R1=100%
After that for Second Team
Resource from table team has 5 overs remaining and the team has 4 wickets on hand.
From Resource Table Resource 14.3%
Total Resource available to South Africa(R2) = 100-14.3=85.7%

11.2.2 Step 2:

In that match Sri Lanka 268 Target set by 1st team
From formula

$$Team2'sParTotalScore = Team1'sScore \times Team2'sResources/Team1'sResources \tag{11}$$

=268*85.7/100
=230 Run

In that match 230 runs need for win and 229 runs for tie South Africa scored Exactly 229 Run.

11.3 Case 3:

In the ING Cup 2003 there was match between New South Wales and South Australia.[14]

In first innings New South Wales bat and scored 273 runs and lose all 10 wickets in 49.4 overs.
When South Australia reached at 70 runs and lose 2 wickets in 19 overs

Figure 22: New South Wales Vs South Australia[32]

rain interrupted match so overs reduced to 36 overs for second innings.

11.3.1 Step 1:Find Available Resources From Table :

Total Resources available to New South Wales=R1
Total Resources available to South Australia=R2
Resource from table team has 50 overs remaining and the team has 10 wickets on hand.
From Resource Table R2=100%
After that for Second Team
Resource from table team has 31 overs remaining and the team has 8 wickets on hand.
From Resource Table Resource 68.6%
Total Resource Remaining Table at the restart 46.7%
Total Resource lost to South Australia (R2) =68.6%-46.7%=21.9%

Total Resource available South Australia (R2)=100%-21.9%=78.1%

11.3.2 Step 2:

In that match Sri Lanka 268 Target set by 1st team.
From formula

$$Team2'sParTotalScore = Team1'sScore \times Team2'sResources/Team1'sResources \quad (12)$$

=273*78.1/100
=213 Run

In that match 214 runs need for win and 213 runs for tie. New South Wales all out for 174 New South Wales won by 213-174=39 Run

11.4 Case 4:

West Indies played Zimbabwe On 25 January 2001.[16]

In first innings West Indies had made 235 runs and lose 6 wickets in 47 overs and rain interrupted match so first and stopped at 47 overs and due to limit of time second innings start and Zimbabwe-second innings already instructed that they had 47 overs to bat before second innings start.

Figure 23: Zimbabwe Vs West Indies[26]

In this situation you have also a question that why D/L method use in this case But before match start team which is batting first(West Indies) did not know that he will have 47 overs instead of 50 overs to bat so there is unfair if we did not make new target for Zimbabwe which is absolutely more than 235 runs.

11.4.1 Step 1: Find Available Resources From Table:

Total Resources available to West Indies=R1
Total Resources available to Zimbabwe=R2
Resource from table team has 3 overs remaining and the team has 4 wickets on hand. Resources remaining 10.2%
From Resource Table R1=89.8%
After that for Second Team
Resource from table team has 47 overs remaining and the team has 6 wickets on hand.
From Resource Table Resource table 97.4%
Total Resource available West Indies (R1)=89.8%
Total Resource available South Australia (R2)=97.4%

11.4.2 Step 2:

In that match Sri Lanka 268 Target set by 1st team.
From formula

$$\text{Team 2's Par total Score} = \text{Team 1' s Score} + (G50 \times (R_2 - R_1))/100 \tag{13}$$

$$=235 + 225*(97.4 - 89.8)/100$$
$$=252 \text{ Run}$$

Zimbabwe's target 253 run to win and 252 run to tie. Zimbabwe all out for 175 West Indies win by 252-175=77 Run

11.5 Case 5:

In ICC Cricket World Cup 2003 there was a match between Australia and Netherlands On 20 February.[39] Rain started before match start so overs reduce to 47 for both teams before start the match.

Figure 24: Australia Vs Netherland[20]

Australia batted first and had scored 109 runs at lose of 2 wickets in 25 overs rain interrupted match.
After rain stopped both innings overs decided to reduce to 44 overs.
Rain interrupted match again at 28 overs when Australia had scored 123 runs at lose of 2 wickets and before restart the match decided that overs are reduced to 36 overs for both innings.

11.5.1 Step 1: Find Available Resources From Table:

Total resources available for Australia at the start of their match is 47 over and 10 wickets: 97.1%
Total Resources remaining to Australia at interruption is 25 over 2 wickets and at that time 22 over and 8 overs remaining at interuption:55.8%
Total Resources remaining at restart:50.5%
Total resources lost by interruption is 55.8%-50.5%=5.3%
After 3 over because of rain match interrupted and at that time Remaining resources at interruption 16 over and 8 wickets at interruption:

44.7%
Total Resources remaining at restart 8 Over 8 Wicket: 25.5%
Total resources lost by interruption =44.7%-25.5%=19.2%
Total available resources =97.1%-5.3%-19.2%=72.6%
Total resources available to Netherland (R2) 36 overs and 10 wickets =84.1%
Netherlands's par score = 36 overs and 10 wickets =84.1%

11.5.2 Step 2:

Calculate target score...

$$\text{Team 2's Par total Score} = \text{Team 1' s Score} + (G50 \times (R_2 - R_1))/100 \tag{14}$$

$$=170+235*(84.1\text{-}72.6)/100$$
$$=197 \text{ runs}$$

In that match, Australia won by 197-122=75 runs.

12 IN GAME STATEGY

[48, 44]

12.1 Strategy for Team 1:

If there are no interruption are expectable than the chasing team's target cannot be set by the 1st inning's batting.
It is as usual as target is the 1st team's score.
But if the inning get interrupted by raining or something else then the

first team get advantage of setting score for chasing team by understanding the DLS method application.
Like.....

12.1.1 Lost more Wicket

If team have lost more wicket, then they should play conservatively as they can set more target for chasing team.

Batting strategy	**Conservative**	**Aggressive**
Runs Team 1 thinks it can score	200	220
Wickets Team 1 thinks it will have in hand	4	2
Resource remaining to Team 1 at cut-off	22.8%	11.4%
Resource used by Team 1	100% - 22.8% = 77.2%	100% - 11.4% = 88.6%
Team 2's par score	200 + 250 x (89.3% - 77.2%)= **230.25 runs**	220 + 250 x (89.3% - 88.6%)= **221.75 runs**

12.1.2 Lost less Wicket

If team have lost less wicket, then they should play Aggressive they can set more target for chasing team

.

This can be very useful to use if you have deep understanding in DLS and right software for the application otherwise it may backfire for it.

12.2 Strategy For Team 2:

If there are is a condition in which 1st team completed it's inning, so team 1 have 100% resources.

So, now Target Score can be computed as

$$\text{Target Score} = \text{1st team score} \times \text{team 2's resources} \tag{15}$$

So, If there is an interruption expectable then chasing team can set their target by understanding the application of DLS method.

i.e.
If they play with by conserving wickets so they can get less D/L par score.

12.2.1 Example:

If they have lost 1 wicket then they can get less score as compare to they have lost 2 wicket.
So , now it can be present by.....

13 CRITISISM

DLS method is blessing for the cricket. But.....
If you don't understand the application it can be bring disadvantages for you.
i.e.
In ODI ENG vs WI 20 march,2009....
The match get interrupted at second while WI is batting because of bad light.
So, WI coach call his whole team to Pavilion as he taught that he would be win by 1 run but he forgot that his team had lost a wicket before that interruption.
So, as the result they got 2 less run than the par score.

References

[1] Ball-by-ball commentary. (n.d.-b). https://static.espncricinfo.com/db/archive/worlc $final_2 3mar2003_b bb - comms.html$.

[2] Cricinfo - duckworth-lewis. (n.d.-b). https://static.espncricinfo.com/db/about$_c ricket/ra$

[3] Cricinfo - duckworth-lewis. (n.d.). https://static.espncricinfo.com/db/about$_c ricket/rain$

[4] Duckworth-lewis method - frequently asked questions. (n.d.). https://static.espncricinfo.com/db/about$_c ricket/rain_r ules/dl_f aq.html$.

[5] The duckworth-lewis method (2002) | espncricinfo.com. (n.d.). cricinfo. https://www.espncricinfo.com/ci/content/page/409996.html.

[6] The duckworth-lewis method (2002) | espncricinfo.com. (n.d.). cricinfo. https://www.espncricinfo.com/ci/content/page/409996.html.

[7] Espn digital media private limited. (n.d.-c). aus vs ned, icc world cup 2002/03, 20th match at potchefstroom, february 20, 2003 - full scorecard. espncricinfo. https://www.espncricinfo.com/series/icc-world-cup-2002-03-61124/australia-vs-netherlands-20th-match-65253/full-scorecard.

[8] Espn digital media private limited. (n.d.-d). ind vs eng, england tour of india 2008/09, 4th odi at bengaluru, november 23, 2008 - full scorecard. espncricinfo. https://www.espncricinfo.com/series/england-tour-of-india-2008-09-361035/india-vs-england-4th-odi-361046/full-scorecard.

[9] Espn digital media private limited. (n.d.-e). gt vs csk, indian premier league 2023, final at ahmedabad, may 28 - 29, 2023 - full scorecard. espncricinfo. https://www.espncricinfo.com/series/indian-premier-league-2023-1345038/gujarat-titans-vs-chennai-super-kings-final-1370353/full-scorecard.

[10] Espn digital media private limited. (n.d.-e). lancs vs hants, national cricket league division two 2003 at manchester, may 18, 2003 - full

scorecard. espncricinfo. https://www.espncricinfo.com/series/national-cricket-league-division-two-2003-124333/lancashire-vs-hampshire-131395/full-scorecard.

[11] Espn digital media private limited. (n.d.). eng vs sa, benson hedges world cup 1991/92, 2nd semi-final at sydney, march 22, 1992 - full scorecard. espncricinfo. https://www.espncricinfo.com/series/benson-hedges-world-cup-1991-92-60924/england-vs-south-africa-2nd-semi-final-65155/full-scorecard.

[12] Espn digital media private limited. (n.d.-f). ps vs ms, big bash league 2012/13, 2nd semi-final at perth, january 16, 2013 - full scorecard. espncricinfo. https://www.espncricinfo.com/series/big-bash-league-2012-13-571220/perth-scorchers-vs-melbourne-stars-2nd-semi-final-571265/full-scorecard.

[13] Espn digital media private limited. (n.d.-f). sa vs ind, india tour of south africa 2010/11, 5th odi at centurion, january 23, 2011 - full scorecard. espncricinfo. https://www.espncricinfo.com/series/india-tour-of-south-africa-2010-11-463136/south-africa-vs-india-5th-odi-463154/full-scorecard.

[14] Espn digital media private limited. (n.d.-h). nsw vs soa, ing cup 2002/03 at sydney, february 16, 2003 - full scorecard. espncricinfo. https://www.espncricinfo.com/series/ing-cup-2002-03-367450/new-south-wales-vs-south-australia-368079/full-scorecard.

[15] Espn digital media private limited. (n.d.-i). sl vs zim, icc world twenty20 2010, 7th match, group b at providence, may 03, 2010 - full scorecard. espncricinfo. https://www.espncricinfo.com/series/icc-world-twenty20-2010-412671/sri-lanka-vs-zimbabwe-7th-match-group-b-412686/full-scorecard.

[16] Espn digital media private limited. (n.d.-q). wi vs zim, carlton series 2000/01, 7th match at adelaide, january 25, 2001 - full scorecard. es-

pncricinfo. https://www.espncricinfo.com/series/carlton-series-2000-01-61080/west-indies-vs-zimbabwe-7th-match-65607/full-scorecard.

[17] https://img1.hscicdn.com/image/upload/f$_auto/lsci/db/pictures/cms$/138000/138019.

[18] https://img1.hscicdn.com/image/upload/f$_auto/lsci/db/pictures/cms$/248700/248769.

[19] https://img1.hscicdn.com/image/upload/f$_auto, t_ds_{w1}$280, $q_8$0/$lsci/db/pictures/db$/052

[20] https://img1.hscicdn.com/image/upload/f$_auto, t_ds_{w9}$60, $q_5$0/$lsci/db/pictures/db$/0220

[21] https://m.rediff.com/cricket/report/crickets-dls-method-inventor-lewis-passes-away/20200402.htm.

[22] https://research.bond.edu.au/en/persons/steven-stern.

[23] https://resources.pulse.icc-cricket.com/icc/photo/2017/01/31/abd1fb54-a565-40eb-9d79-0acb2b16be92/gettyimages-486317210.jpg.

[24] https://ss-i.thgim.com/public/incoming/p1tv7j/article66903227.ece/alternates/free$_1$20

[25] https://staticg.sportskeeda.com/editor/2019/06/bd462-15612135801332-800.jpg.

[26] https://thecricketcauldron.com/2018/03/19/specials-best-of-the-odis-west-indies-v-zimbabwe/.

[27] https://upload.wikimedia.org/wikipedia/commons/3/38/cantigas$_de_santa_mar$

[28] https://www.amazon.in/duckworth-lewis-method-men-behind/dp/1907524002.

[29] https://www.crichighlightsvidz.com/2020/03/dale-steyn-5-50-india-vs-south-africa-29th-match-icc-cricket-world-cup-2011-highlights.html.

[30] https://www.crichighlightsvidz.com/2020/05/mahela-jayawardene-100-sri-lanka-vs-zimbabwe-7th-match-icc-world-t20-2010-highlights.html.

[31] https://www.espncricinfo.com/series/england-tour-of-india-2008-09-361035/india-vs-england-4th-odi-361046/match-photo.

[32] https://www.google.com/imgres?imgurl=https

[33] https://www.google.com/imgres?imgurl=https

[34] https://www.google.com/imgres?imgurl=https

[35] https://www.google.com/imgres?imgurl=https://images.news18.com/ibnlive/uploads/2 sa.jpgtbnid=0h-tks$_3$$skvh0mvet = 1imgrefurl = https : //www.news18.com/cricketnext/news/on - this - day - in - 1992 - south - africa - england - play - out - bizarre - world - cup - semi - final - 4892507.htmldocid = ch5w5wy6ggcvqmw = 1600h = 1600source = sh/x/im/m1/1.$

[36] https://www.sportsadda.com/cricket/features/india-vs-pakistan-cricket-records-tests-odis-t20is-stats.

[37] Icc playing handbook (2006-2007).

[38] Icc playing handbook (2013-2014).

[39] Introducing duckworth-lewis-stern method. (n.d.-f). cricbuzz. https://www.cricbuzz.com/cricket-series/cricket-news/69983/introducing-duckworth-lewis-stern-method.

[40] Lancashire cricket club. (n.d.-b). lancashire cricket club. https://www.cricketarchive.co.uk/lancashire/scorecards/76/76989.html.

[41] Playing handbook - publications | icc cricket. (n.d.). https://web.archive.org/web/20140419012918/http://www.icc-cricket.com/about/113/publications/playing-handbook.

[42] Rajesh, s. (2023b, september 15). how the duckworth-lewis-stern method works. espncricinfo. https://www.espncricinfo.com/story/how-the-duckworth-lewis-stern-method-works-1102000.

[43] Scorecard - 2005-2006 pakistan v india - 06/02/2006. (n.d.). http://www.howstat.com/cricket/statistics/matches/matchscorecard$_o$$di.asp?matchcod 2423.

[44] Sengupta, a. (2017, september 29). tony lewis, of duckworth-lewis, interview: Journalists denigrate system by publishing "rubbish" without. dna india. https://www.dnaindia.com/sport/report-tony-lewis-of-duckworth-lewis-interview-journalists-denigrate-system-by-publishing-rubbish-without-understanding-1880623.

[45] Staff, e. (2007, january 1). a decade of duckworth-lewis. espncricinfo. https://www.espncricinfo.com/story/a-decade-of-duckworth-lewis-274677.

[46] Wikipedia contributors. (2023a, july 6). average run rate method. wikipedia. https://en.wikipedia.org/wiki/average$_r un_r ate_m ethod$.

[47] Wikipedia contributors. (2023b, july 6). most productive overs method. wikipedia. https://en.wikipedia.org/wiki/most$_p roductive_o vers_m ethod : : text = the$

[48] Wikipedia contributors. (2023e, november 20). duckworth–lewis–stern method. wikipedia. https://en.wikipedia.org/wiki/duckworth