How **Circuit Layout** and **Fuel Load** affect lap times of a F1 car in Silverstone

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Table of contents

Objective

The following factors affect a lap time of an F1 car in Silverstone:

Car Performance

Aerodynamics, Power Unit, Engine, Tyres, Car Setup, Weight, Braking system

Circuit

Circuit Layout, Circuit Surface, Circuit Evolution, Weather Conditions

Driver

Driving Skill & Consistency, Race craft & Strategy

Race Situations

Fuel Load, Drag Reduction System, Traffic and Slipstream, Track Limits & Penalties

This project looks at two things: **circuit layout** and **fuel load**, and will analyse:

1. The effect of the **circuit layout** on a lap time of an F1 car in Silverstone.
2. The effect of **fuel load** on a lap time of an F1 car in Silverstone.

Strategy and Plan

Circuit Layout Test

A comparison will be performed of the lap time of two circuits of equal length:

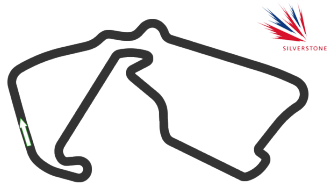
1. The Silverstone F1 circuit which contains a variety of corners featuring different angle turns and
2. A fictional oval circuit which has 4 fast sweeping turns.

Fuel Load Test

A comparison will be performed of the time of a qualification lap (low fuel load) to the time of a race lap (high fuel load). To make it a fair test, lap 2 of the race will be used, because by then the tyres are warmed up and the car is at full speed, just like in qualifying.

Circuit Layout Test - Comparison of Lap Times

Perform a comparison of the lap time of two circuits of equal length (**5.891Km**)



	Silverstone Circuit	Oval Circuit
Circuit Type	A real F1 circuit with a variety of corners, including sharp turns that require heavy braking and slower speeds	A fictional circuit with four fast sweeping turns, meaning a car can maintain high speed throughout.
Length	5.891km	5.891km
Number of Turns	16	4
Average Speed	233km/h	294.8km/h (Est)
Lap Time (seconds)	1 min 31.020 seconds	1 min 11.938 seconds (Est)
Comparison Result	Difference of 19.082 seconds (26%)	

Silverstone Circuit

- Average Speed of 233km/h was taken from FIA.com.
- Lap time was calculated using the formula, *Time = Distance ÷ Speed*, see next slide for calculation.

Oval Circuit

- Average speed was calculated by identifying max speed of a circuit of similar length (Silverstone) and reducing it to allow for braking and deceleration in corners. See next slide for calculation.
- Lap time was calculated using the formula, *Time = Distance ÷ Speed*, see next slide for calculation.

Circuit Layout Test – Calculation of Lap Times

Calculation: Silverstone Circuit Lap Time

Average Speed : **233km/h** taken from FIA.com

Change Speed from km/h to mtr/sec using

- 1 Km = 1000mtr and 1 hour = 3600 seconds.
  - 233km/h x 1000 ÷ 3600 = 64.722 m/s

Calculate lap time using

- *Time = Distance ÷ Speed*
  - 5891m ÷ 64.722 = 91.020 seconds **(1 min 31.020 seconds)**

Calculation: Oval Circuit Estimated Average Speed.

- 2024 F1 car max speed: 335 km/h taken from FIA.com
- Using IndyCar Phoenix Raceway circuit as a reference which is an oval shape, average speed reached is 88% of max speed. So it makes sense that an F1 car could go at a similar speed. (Data obtained from IndyCar.com)

- Estimated Average Speed
  - 335km/h × 88% = **294.8 km/h**

Calculation: Oval Circuit Estimated Lap Time

Change Speed from km/h to mtr/sec using

- 1 Km = 1000mtr and 1 hour = 3600 seconds.
  - 294.8km/h x 1000 ÷ 3600 = 81.889 m/s

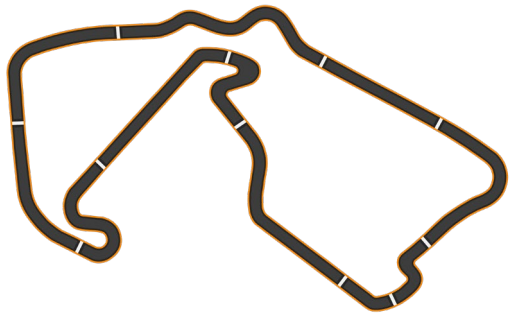
Calculate Lap time using

- *Time = Distance ÷ Speed*
  - 5891m ÷ 81.889 = 71.938 seconds **(1 min 11.938 seconds)**

Circuit Layout Test – Measurement of Corner Angles

The comparison of the lap time of two different circuits showed a time difference of 19.082 seconds. The number and angle of corners were checked to see how they affected lap times and added to the difference.

Silverstone F1 circuit has 16 corners. Each corner angle was measured using a protractor on the Silverstone circuit map (Appendix A). The angles weren't measured perfectly, but they're close enough to work well for this project.



Corner	Type	Curvature Angle (°)
Abbey	High-speed sweeping right	30
Farm Curve	Gentle flat-out left kink	30
Village	Medium-speed right turn	90
The Loop	Very slow left hairpin	180
Aintree	Easy left bend onto straight	45
Brooklands	Medium-speed left-hand turn	135
Luffield	Long right hairpin (double-apex)	180
Woodcote	Fast right kink onto straight	30
Copse	Fast sweeping right-hander	60
Maggotts	High-speed left bend	45
Becketts	High-speed right bend	90
Chapel	Left bend leading to straight	30
Stowe	Fast right-hand corner	90
Vale	Left-right chicane (combined)	90
Club 1	Long sweeping right onto main straight	60
Club 2	Long sweeping right onto main straight	60

Circuit Layout Test – Calculation of Estimated Corner Time Lost

As mentioned previously, Silverstone F1 circuit has 16 corners with angles ranging from 30° to 180°. Four corners of different angles were selected to review corner time lost. I watched real F1 videos from Sky Sports F1 to time how long different corners took.

- A 150m long fast sweeping bend (30°) takes approx. 2.0 seconds.
- A 150m long medium-speed turn (90°) take approx. 2.7 seconds.
- A 150m long tight bend (135°) takes approx. 3.3 seconds.
- A 150m long hairpin (180°) takes approx. 4.0 seconds.

To estimate how corner angles impact time, the time lost was compared on 4 corners using the 30° corner as a baseline.

Corner	Corner Time	Corner Time of 30°	Time Difference from 30°	Angle Difference from 30°	Corner Time Lost per Degree
90°	2.7s	2.0s	0.7s	60°	0.7 ÷ 60 = **0.0117s**
135°	3.3s	2.0s	1.3s	105°	1.3 ÷ 105 = **0.0124s**
180°	4.0s	2.0s	2.0s	150°	2.0 ÷ 150 = **0.0133s**

To improve accuracy, the average of the above calculations can be used.

- Average Time Lost Per Degree
  - (0.0117 + 0.0124 + 0.0133) ÷ 3 = 0.0125 seconds per degree
- Therefore Estimated Corner Time Loss (seconds) = Angle × 0.0125s

Circuit Layout Test – Calculation of Est Corner Time Lost in Silverstone

Applying the Estimated Corner Time Loss to the table of Silverstone Corners results in the following:

Corner	Type	Curvature Angle (°)	Est Time Loss (Angle × 0.0125)
Abbey	High-speed sweeping right	30	0.375
Farm Curve	Gentle flat-out left kink	30	0.375
Village	Medium-speed right turn	90	1.125
The Loop	Very slow left hairpin	180	2.250
Aintree	Easy left bend onto straight	45	0.5625
Brooklands	Medium-speed left-hand turn	135	1.6875
Luffield	Long right hairpin (double-apex)	180	2.250
Woodcote	Fast right kink onto straight	30	0.375
Copse	Fast sweeping right-hander	60	0.750
Maggotts	High-speed left bend	45	0.5625
Becketts	High-speed right bend	90	1.125
Chapel	Left bend leading to straight	30	0.375
Stowe	Fast right-hand corner	90	1.125
Vale	Left-right chicane (combined)	90	1.125
Club 1	Long sweeping right onto main straight	60	0.750
Club 2	Long sweeping right onto main straight	60	0.750
Total Estimated Time Loss for all 16 corners of Silverstone Circuit			**15.5625**

Circuit Layout Test - Summary and Conclusion

Comparison Basis

Two circuits of equal length were compared, the complex Silverstone F1 circuit (16 corners) and a simplified fictional oval circuit (4 corners).

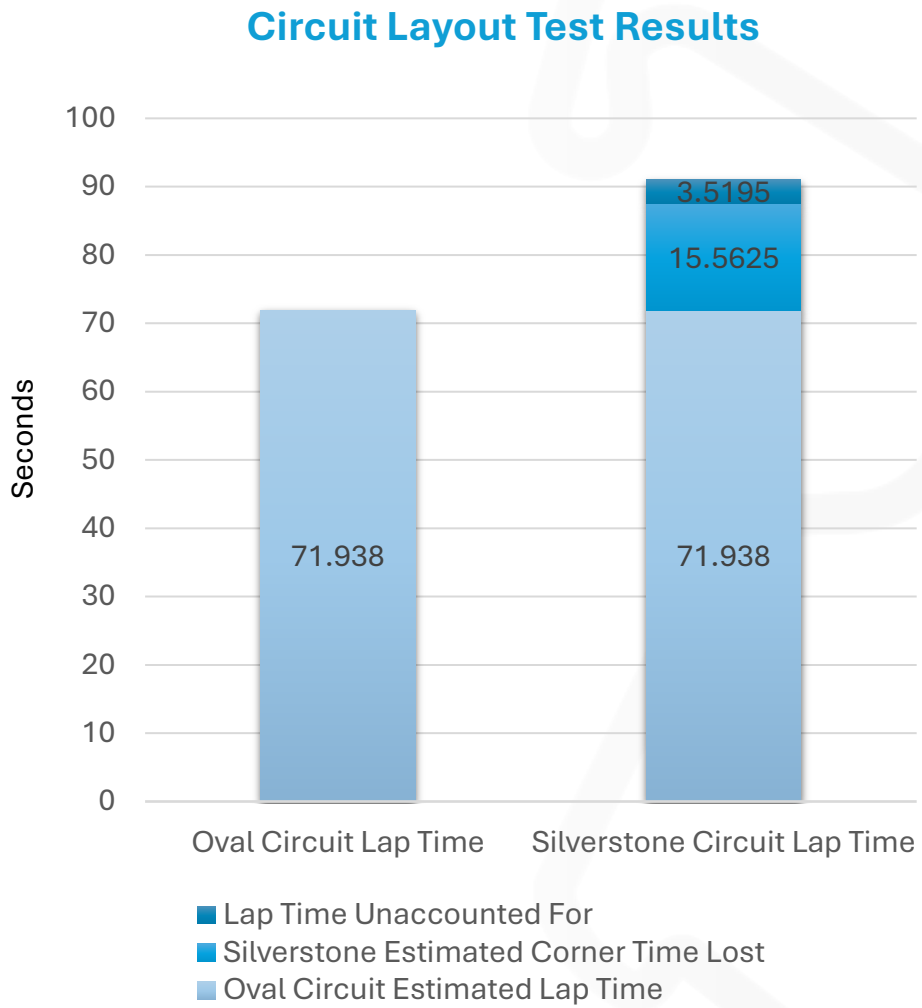
Main Finding

Silverstone lap times are 19.082 seconds slower, a 26% increase over the oval circuit.

Most of the extra time (21%) comes from the extra corners at Silverstone. The rest (5%) could be due to braking, gear changes, and slowing down for turns.

Conclusion

Silverstone is 19.082 seconds slower than the oval circuit mainly because it has more corners. Most of the extra time (21%) comes from those extra turns. The rest (5%) is likely because of braking, slower acceleration, and gear changes. This shows how much circuit layout affects lap times.



Fuel Load Test – Background & Assumptions

Background:

In F1, more fuel adds weight to the car, which makes it slower to accelerate, brake, and turn. Every extra 10kg of fuel adds about 0.3 seconds to a lap (Motorsport.com). As fuel is burned during the race, the car gets lighter and faster.

F1 car configuration .i.e. rear and front wing angles, suspension stiffness, wheel camber, etc. can be altered across different practice sessions on a race weekend, however they must not change between race qualification and race day. For both qualification and race lap, the only thing that can change is tyre choice and fuel load.

Assumptions:

- Both sessions (race and qualification) are using the same tyre choice.
- In a qualification session, F1 cars are typically fuelled to run 3 laps of the circuit (1 warm up lap, 1 qualification lap and 1 cool down lap). A race fuelled car will contain a full tank of fuel.
- To ensure a fair comparison, race lap 2 will be used as it is completed in a similar fashion to a qualification lap (i.e. full speed crossing the start/finish line, and tyres are up to temperature for maximum grip).
- Circuit conditions are dry and similar

Fuel Load Test - Comparison of Lap Times

Perform a comparison between a qualification lap time (with low fuel load) and a race lap time (with high fuel load) to identify the impact of low fuel.

The last 5 years of data showing qualifying and race lap times was taken from FIA.com in order to show consistency year on year. The difference was then calculated, see table below.

Lap Type	Fuel Load	2024 Lap Time (Seconds)	2023 Lap Time (Seconds)	2022 Lap Time * (Seconds)	2021 Lap Time (Seconds)	2020 Lap Time (Seconds)
Qualifying Lap	6kg - 3 laps of fuel	1:26.030	1:26.720	1:40.983	1:26.134	1:24.303
Race Lap 2	104kg - 52 laps of fuel	1:31.418	1:33.046	1:33.623	1:32.910	1:31.143
Difference		5.388s	6.326s	7.360s	6.776s	6.840s
Difference %		6.26%	7.29%	**-7.29%**	7.87%	8.11%

**As 2022 was affected by weather conditions this data has been excluded from further analysis.*

Fuel Load Test - Summary and Conclusion

Comparison Basis

This test compared lap times from **qualifying sessions** (low fuel load of 6kg) with **early race laps** (high fuel load of 104kg) over four F1 seasons (2020–2024). All data was sourced from FIA.com for consistency.

Main Finding

On average, **race laps were 6% to 8% slower** than qualifying laps. This performance drop remained consistent across the years analysed.

The key factor behind the slower race laps is **fuel load**. A heavier car affects braking distance, acceleration rate and cornering speed. Additional race factors such as tyre wear and traffic may contribute slightly but fuel load is the key factor.

Conclusion

Fuel load has a clear and measurable impact on F1 performance. Teams must carefully manage the trade-off between carrying enough fuel to finish the race and staying as light (and fast) as possible. This analysis shows how maths is directly used in real-world racing strategy.

Reflection

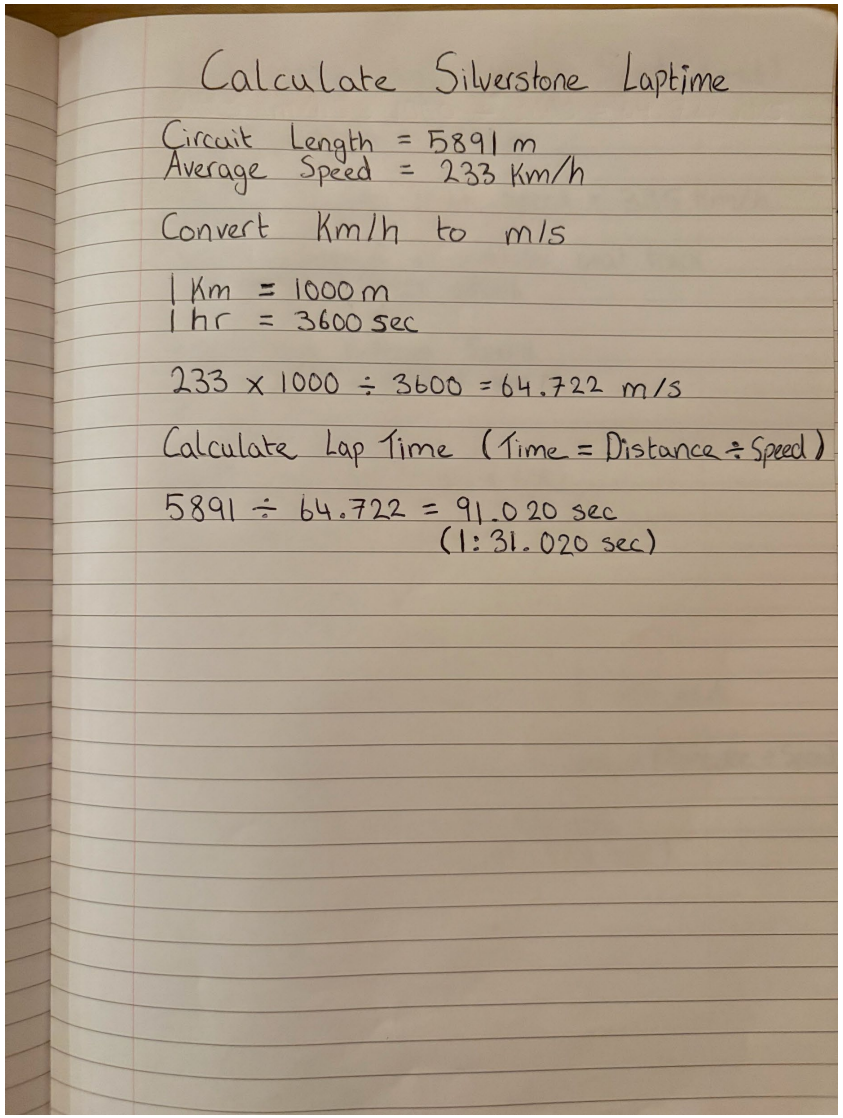
What would I do different?

- Consider including tyre wear as another factor, as it also affects lap times and changes throughout a race.
- Compare different circuits (like Silverstone vs. Monza) to see how layout affects lap times on faster F1 circuits.
- Create a visual timeline showing how lap times improve as fuel burns off during a race.

What I learned?

I found out that racing strategy uses a lot of maths, like time, speed, percentages, and estimating. I liked seeing how the maths we learn in school is actually used in F1, which is something I'm really into. I also learned how real F1 data connects with maths to help analyse and improve performance on the circuit.

Sample of Calculations Performed



Calculate Silverstone Laptime

Circuit Length = 5891 m
Average Speed = 233 Km/h

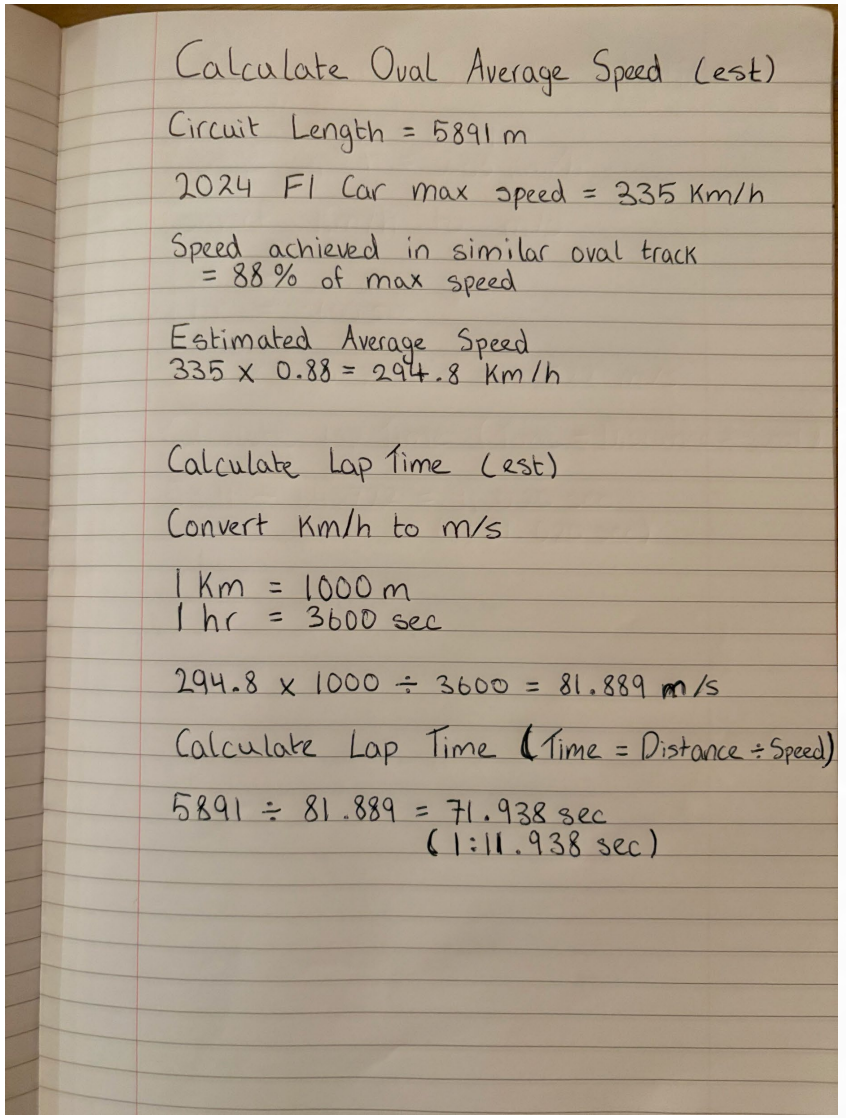
Convert Km/h to m/s

1 Km = 1000 m
1 hr = 3600 sec

233 x 1000 ÷ 3600 = 64.722 m/s

Calculate Lap Time (Time = Distance ÷ Speed)

5891 ÷ 64.722 = 91.020 sec
(1:31.020 sec)



Calculate Oval Average Speed (est)

Circuit Length = 5891 m

2024 F1 Car max speed = 335 Km/h

Speed achieved in similar oval track
= 88 % of max speed

Estimated Average Speed
335 x 0.88 = 294.8 Km/h

Calculate Lap Time (est)

Convert Km/h to m/s

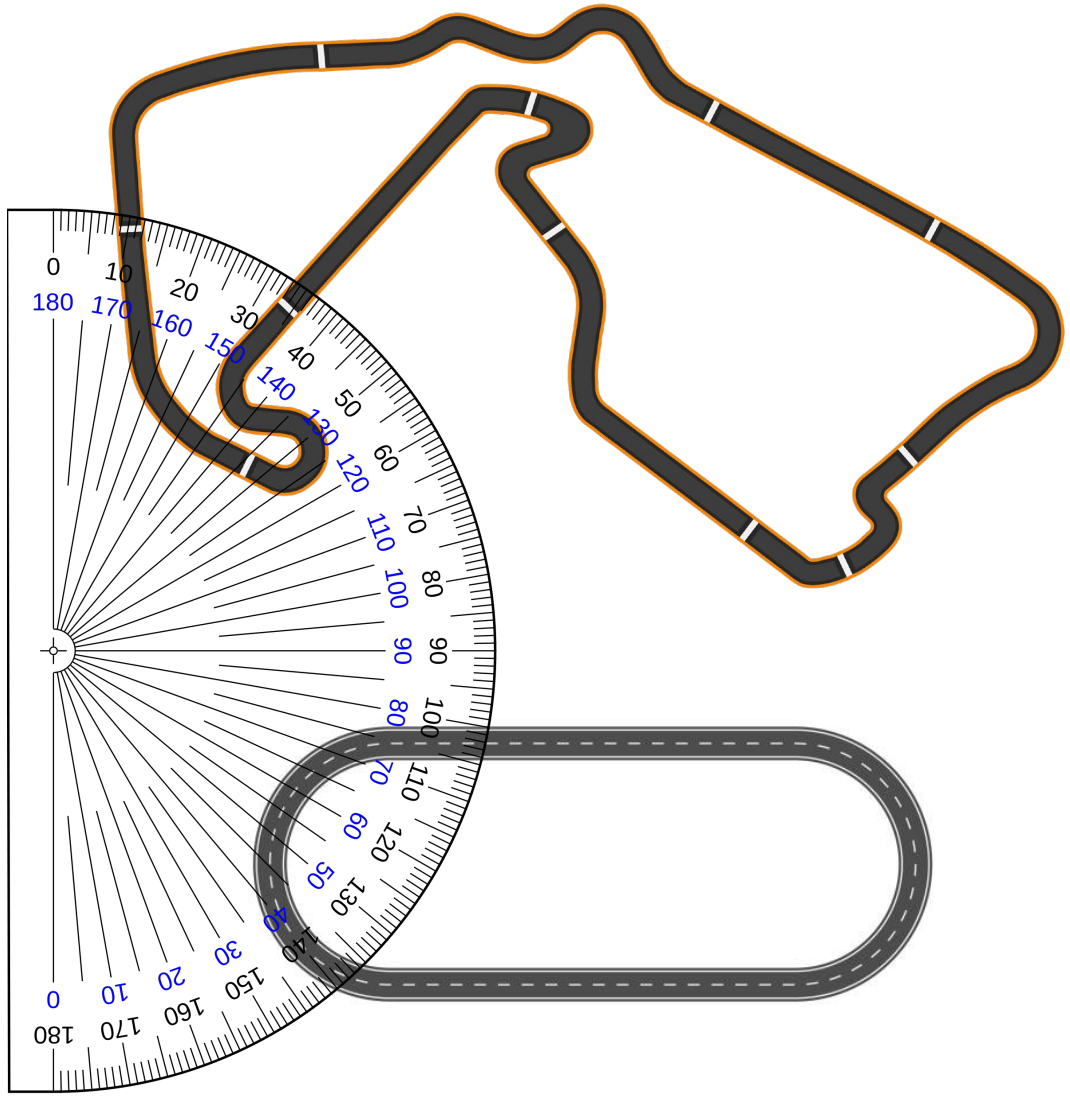
1 Km = 1000 m
1 hr = 3600 sec

294.8 x 1000 ÷ 3600 = 81.889 m/s

Calculate Lap Time (Time = Distance ÷ Speed)

5891 ÷ 81.889 = 71.938 sec
(1:11.938 sec)

Appendix



Corner	Type	Average speed taken (km/h)	Curvature Angle (°)
Abbey	High-speed sweeping right	290	30
Farm Curve	Gentle flat-out left kink	290	30
Village	Medium-speed right turn	120	90
The Loop	Very slow left hairpin	40	180
Aintree	Easy left bend onto straight	245	45
Brooklands	Medium-speed left-hand turn	160	135
Luffield	Long right hairpin (double-apex)	125	180
Woodcote	Fast right kink onto straight	280	30
Copse	Fast sweeping right-hander	280	60
Maggotts	High-speed left bend	300	45
Becketts	High-speed right bend	230	90
Chapel	Left bend leading to straight	265	30
Stowe	Fast right-hand corner	250	90
Vale	Left-right chicane (combined)	120	90
Club 1	Long sweeping right onto main straight	255	60
Club 2	Long sweeping right onto main straight	255	60