ISSN No:-2456-2165

Kaunas University of Technology
Faculty of Mechanical Engineering and Design

Stability of Car Layout

Sai Veeresh Uppala

Kaunas, 2021

Project author

Contents

ISSN No:-2456-2165

List of Figures

ISSN No:-2456-2165

ABSTRACT

Automobile is a machine that delivers a mechanical movement as an output at the same time taking fuel as an input. The automobile is a four-wheeled self-driven vehicle. For an automobile, the design plays a significant role in the automotive industry. The automobile has various types of designs in the market, in accordance with the taste of customer and depending on the kind of application. The automobile layout is a blueprint which tells about the arrangement of the components in an automobile. There are various types of layout in accordance with its application, they are, "Front engine-front wheel drive, Front engine-rear wheel drive, Front engine-all wheel drive, Mid-engine-rear wheel drive, Rear engine-rear wheel drive and so on". For each layout there is unique advantages, disadvantages, and applications. In this paper, the stability of the automobile will be studied in every layout of the automobile.

Keywords:- *Automobile; Layout; Front Engine; Mid-Engine; Rear Engine.*

ISSN No:-2456-2165

I. INTRODUCTION

An automobile is an important being in a man's daily life. The person uses the automobile for various purposes like personal and professional. Personal includes tours, daily use for office, and professional includes deliveries, racing etc., the automobile is a machine that runs with the help of power generator and has a body for placing the person as shelter which provides guard in rain, snow, and heat.

Present days the usage of automobiles have been increased rapidly, increase in demand, technology and safety, the manufacturers are introducing new technology for the safety and stability of the vehicle. New models, designs are rapidly introduced into the market. Most of the customers use passenger cars for their daily purpose.

From twentierth century automobiles came into global usage. In the year 1886 the modern developed car is invented by Karl Benz in Germany. Then a US company so called Ford Motor Company developed the automobiles with replacing animal carriages and carts.In this mordern era, the automobile is much developed in terms of safety, comfort, additional features and technology. More number of electrical and electronics are added to improve the safety of the consumers (Car, n.d.).

A car layout is similar to a design plan or a blueprint, which tells about the component arrangements in a car. It also says about the drivetrain, power generator and other components and their placement. These layouts are used for their unique applications and they have their own advantages and disadvantages. There are nine types of car layouts in accordance to the wheel drive.

- Front wheel drive
  - Front engine
  - Mid-engine
  - Rear engine
- Rear wheel drive
  - Front engine
  - Mid-engine
  - Rear engine
- All wheel drive
  - Front engine
  - Mid-engine
  - Rear engine

In these days a new type of layout has been introduced, that is:

- Four wheel drive
  - Front engine
  - Mid-engine
  - Rear engine

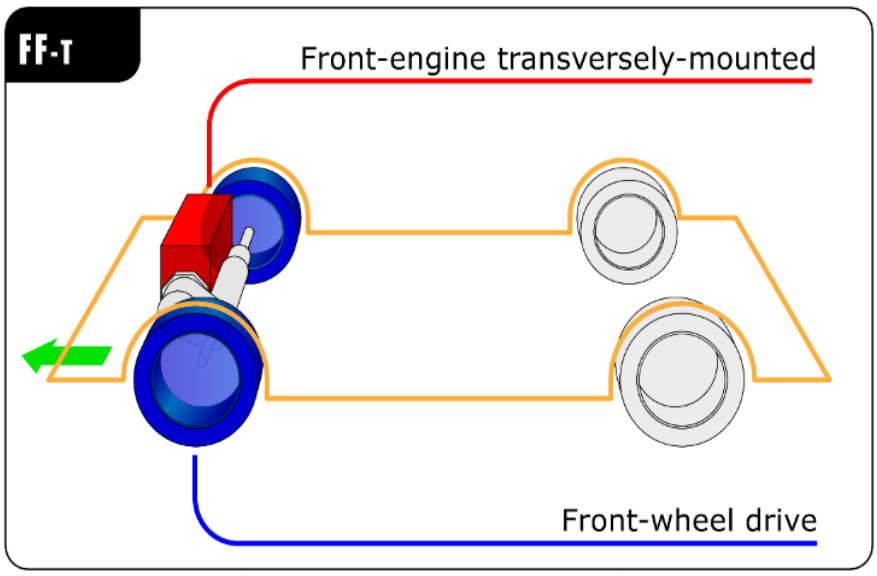

Figure 1: Front Engine-Front wheel drive (Car Layout, n.d.).

ISSN No:-2456-2165

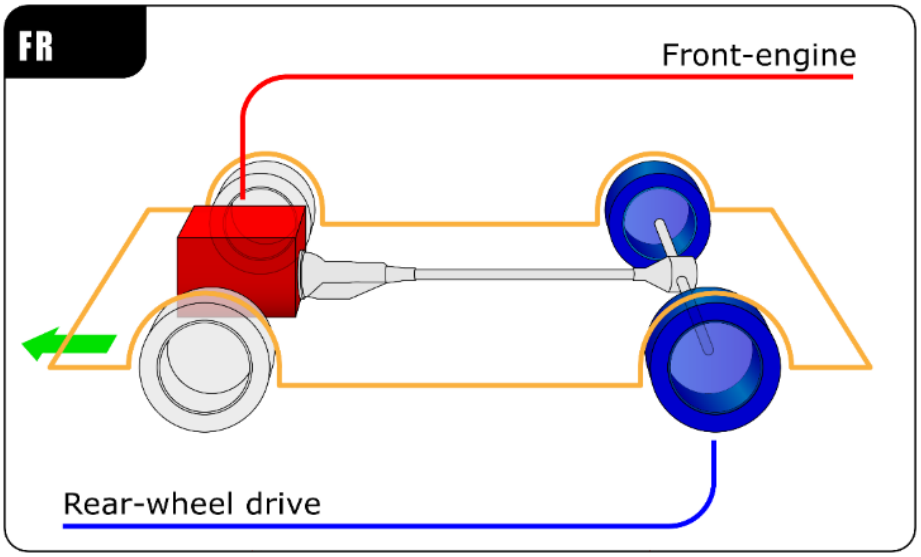

Figure 2: Front engine-Rear wheel drive (Car Layout, n.d.).

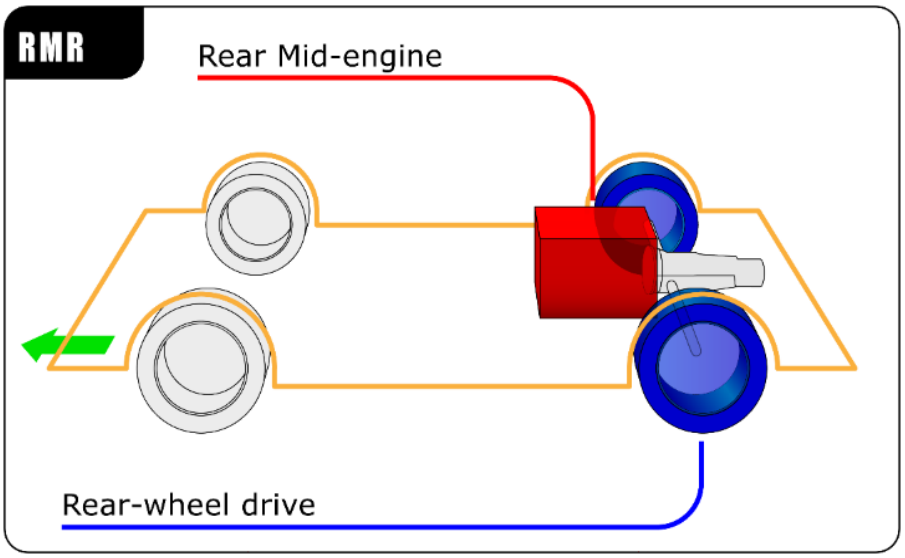

Figure 3: Rear engine-Rear wheel drive (Car Layout, n.d.).

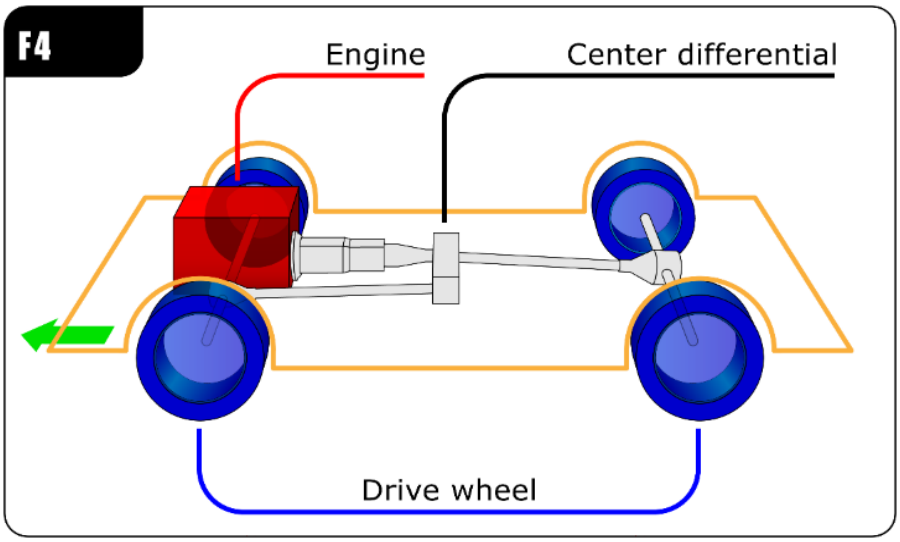

Figure 4: Front engine- Four wheel drive (Car Layout, n.d.).

ISSN No:-2456-2165

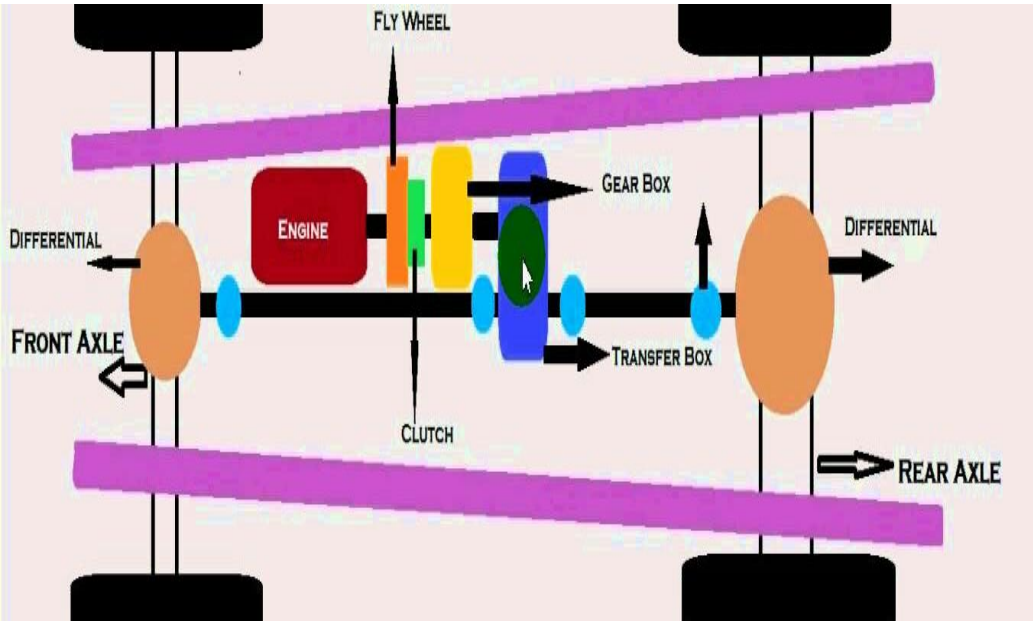

Figure 5: All wheel drive (Patil, 2016).

ISSN No:-2456-2165

II. METHODOLOGY

Typically, car manufacturers design their vehicles with equivalent distribution of weight to every tire. This appears to be attributable to the simple fact that this is the most optimal weight distribution overall. It improves the car's acceleration, deceleration, and control. However, to achieve a goal, there are various distributions that can help. Weight distribution is greatly influenced by a variety of layouts (Passenger Car Layouts, 2010).

2.1. Front Wheel Drive

The "Front wheel drive", the name itself says everything, the automobile runs through front wheels. That power is given to the wheels that are in front to drive the car.

2.1.1. Front–Engine

The internal combustion power generator and powered wheels are both situated at the front of the automobile in front wheel drive– front engine configuration. Since the late twentieth century, this has been the most common layout for automobiles (Car Layout, n.d.).

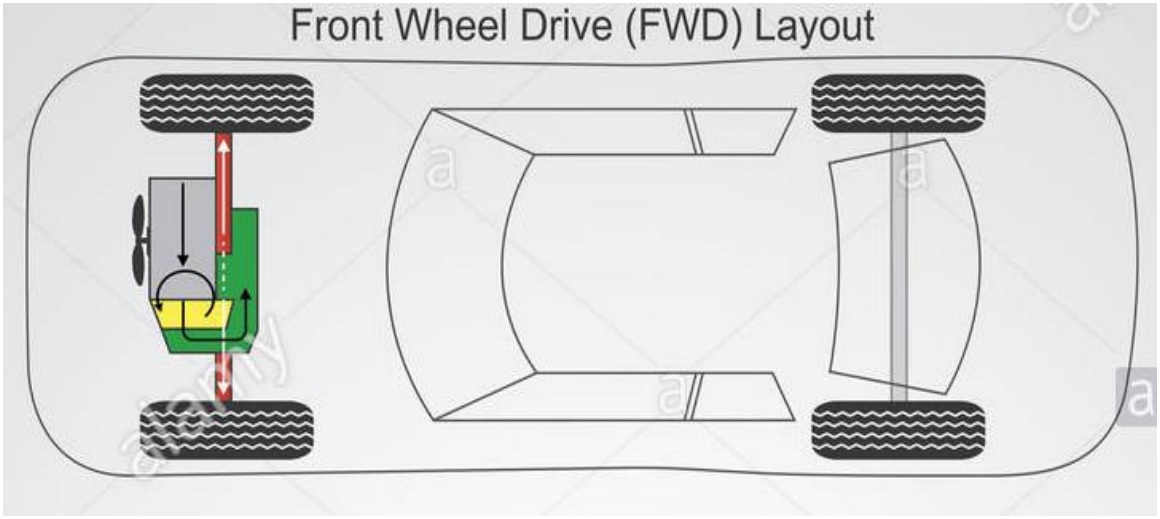

Figure 6: Front wheel drive–Front Engine (Photo, 2017).

This configuration maximizes passenger space and creates a smooth ground line, consisting in a transverse underfloor-longitudinal power generator position. The length of the propeller shaft is decreased or ignored. Due to the power generator weight in the foreground, it has good traction on the road (Patil, 2016).

2.1.2. Rear–Engine

The rear-engine, front-wheel-drive configuration is one of them, where the power generator is situated between or behind back axle and drives front tires through a driveshaft, the polar opposite of a traditional front-engine, back wheel automobile design. This style was used only on experimental and prototype vehicles (Car Layout, n.d.).

2.1.3. Mid–Engine

The Mid–Engine, Front wheel drive configuration is another type of layout, where the power generator is located in the middle of the automobile. This type of layout has been started since 1930s.

2.2. Rear Wheel Driv

2.2.1. Front–Engine

Front engine, Rear wheel drive automotive have the power generator situated at front and propelled wheels at back. For the majority of 20th century, this remained the standard of the automobile layout, and it continues to be among the most widely known configuration for back wheel vehicles (Car Layout, n.d.).

ISSN No:-2456-2165

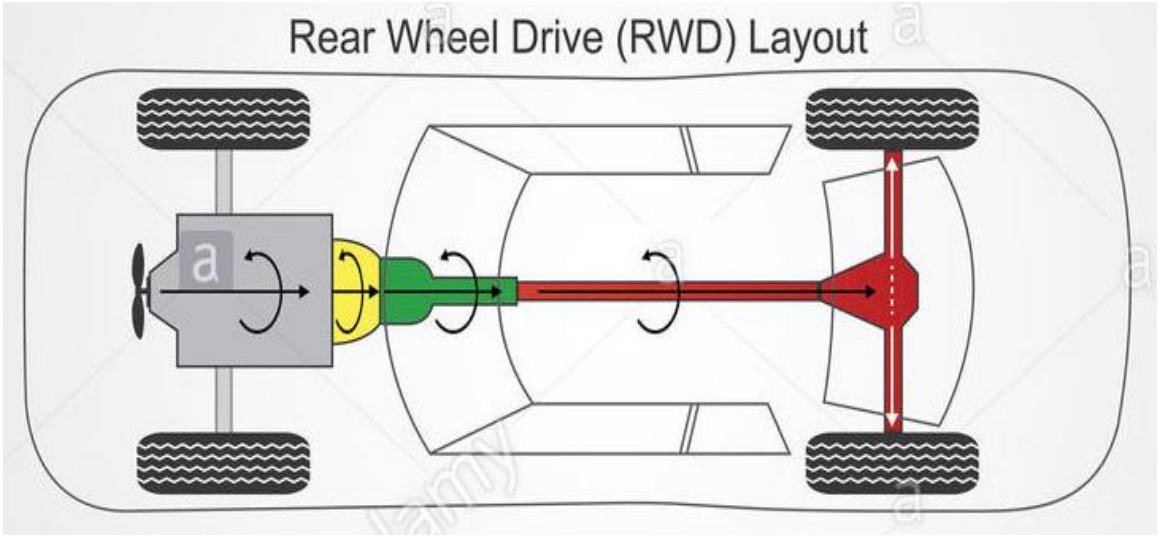

Figure 7: Rear wheel drive–Front Engine layout (Photo, 2017).

In this arrangement, a front gear-differential mounted power generator that turns a couple of helical springs over a propeller shaft which is supported by universal joints is used with two beam axles connected leaf springs. An additional benefit of coil springs is that the front tires are individually suspended (Patil, 2016).

2.2.2. Rear–Engine

There is one alternative in this vehicle type, the rear-engine, rear-wheel layout, in which the wheels are both located at the back of the car. Conversely to the most typical configurations, the mid-rear layout, the load of the power generator is placed in the central place of automobile rather than between the wheels the outline of low-floor buses has caused the universal expansion to be employed in more transit vehicles has greatly reduced the occurrence of this common vehicle design, yet in passenger vehicles (Car Layout, n.d.).

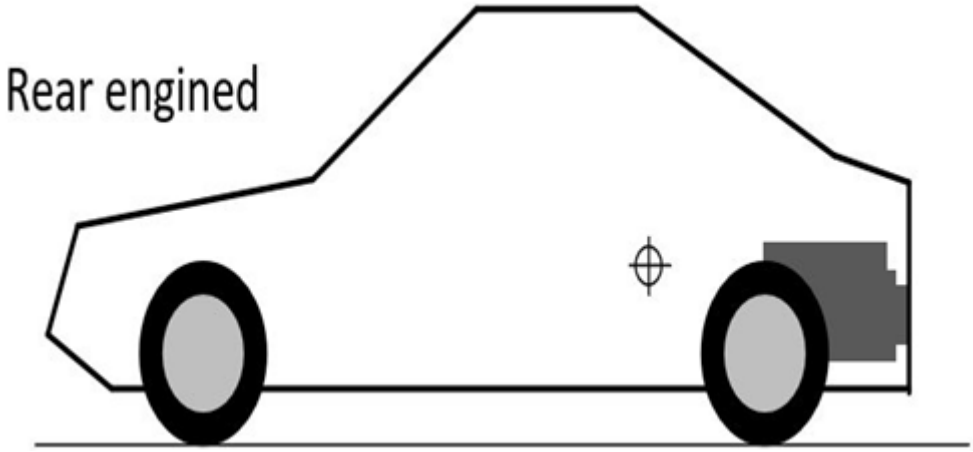

Figure 8: Rear Wheel Drive–Rear Engine layout (Diagram Database).

Without the propeller shaft, the machine will not need to move. This whole transmission is contained within the transmission case, which also includes the clutch and gearbox and final drive (Patil, 2016).

2.2.3. Mid–Engine

Like the mid-engine, back wheel shaft layout, the back tires are attached to the transmission, but directly in before of the passenger cabin. Whereas the configuration has the main weight placed over the back wheel, the centroid remains behind the drive wheels in configurations. Inherently possessing these characteristics, this design is chosen for being very little moment of inertia as well as weight distribution, this is often favoured (Car Layout, n.d.).

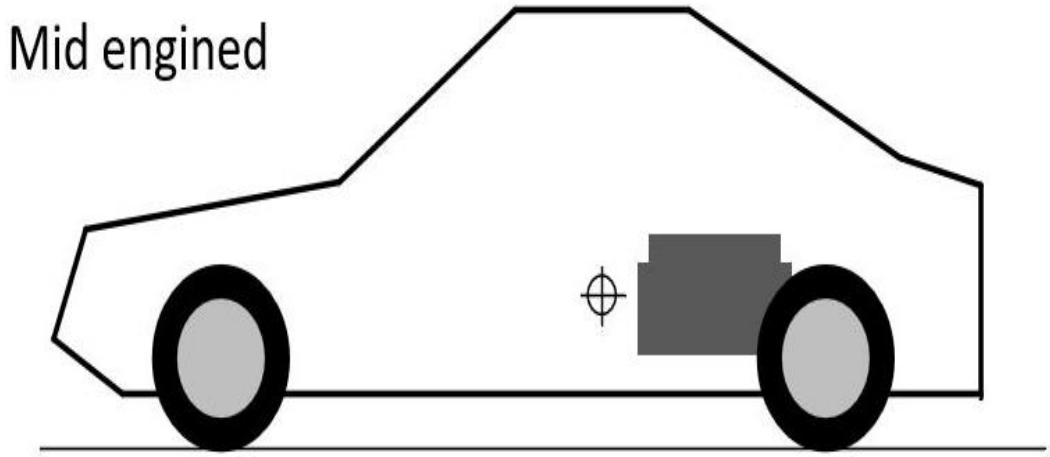

Figure 9: Rear wheel drive–Mid engine layout (Diagram Database).

2.3. **Four Wheel Drive**

2.3.1. **Front–Engine**

The front engine four-wheel power drive means the power generator is towards front of automobile and all wheels are driven by a mechanism out in order of their location, Off-road drivers frequently uses this layout (Car Layout, n.d.).

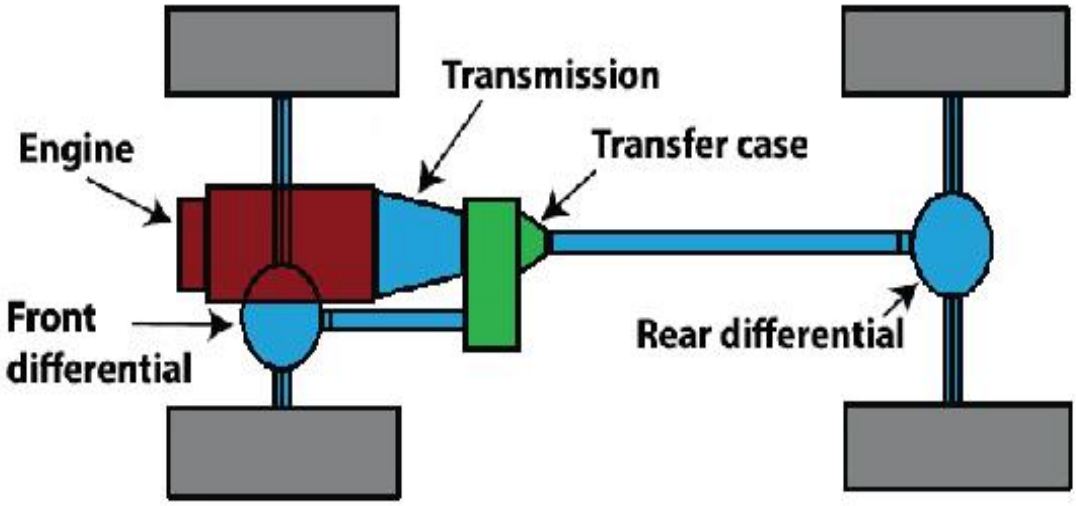

Figure 10: Four wheel drive–Front engine (Muscoplat, 2018).

2.3.2. **Rear–Engine**

This driving-configuration places the power generator behind the vehicle's rear axle and gets the vehicle moving forward via all four-wheel drive-drive. This vehicle configuration is typically used to increase the vehicle's performance when the existing configuration already contains high traction or handling (Car Layout, n.d.).

2.3.3. Mid–Engine

This layout (of the mid-engine-four-wheel drive) positions its engine as in midst of the automobile, between the two axles, between the front and rear wheels, and provides all four-wheel drive. The term "mid-engine" is more commonly employed in the context of sports cars than vehicles at which engine sits in the middle of the vehicle. Power is distributed to both the front and back axles in an M4 differential (Car Layout, n.d.).

ISSN No:-2456-2165

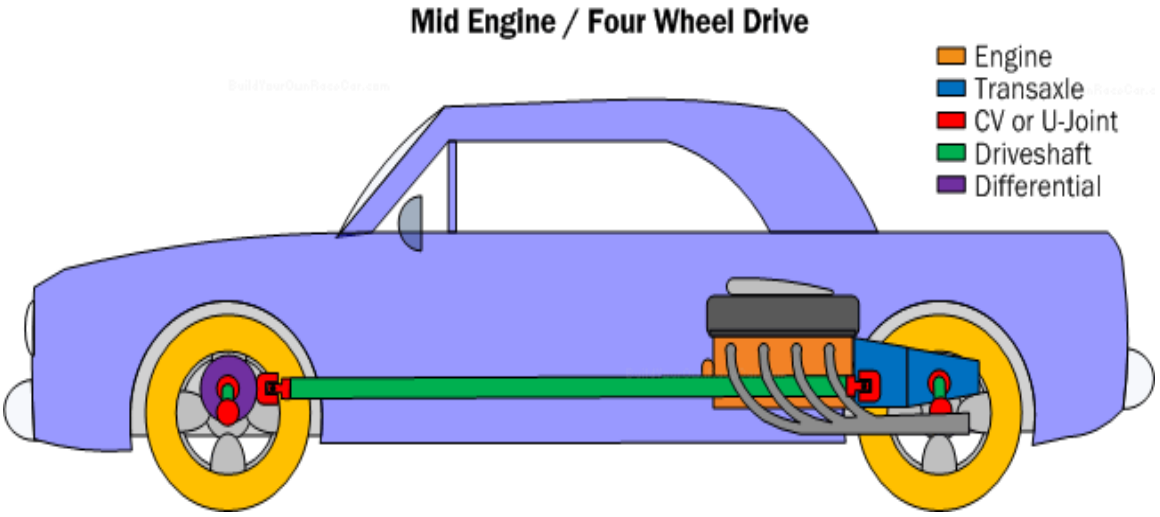

Figure 11: All wheel drive–Mid engine layout (Build your own race car).

There is not much difference between All wheel drive and four–wheel drive, the only difference is with four–wheel drive is the fact that, it has an option to drive with 2–wheel drive sometimes when the driver is desired. There is an additional link added in All wheel drive, where it allows the vehicle to drive with all the wheel at all times as shown in fig. 12, the Center differential makes the difference.

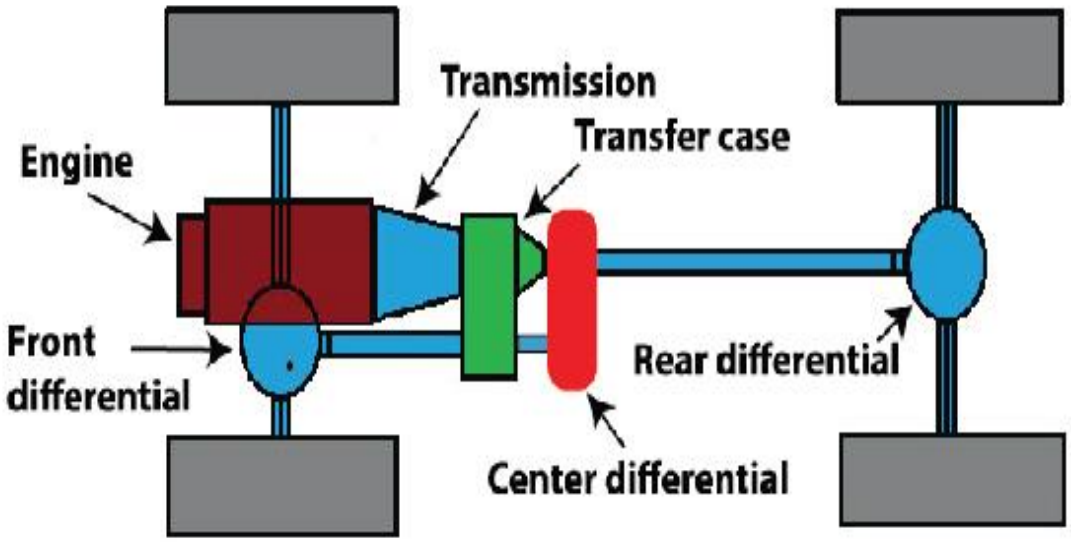

Figure 12: All Wheel Drive layout (Muscoplat, 2018).

ISSN No:-2456-2165

III. DISCUSSION

Building or designing an automobile is an important task, but checking its Stability is also an important task while developing or designing an automobile. To balance an automobile within its layout is very important step as a design engineer. Any engineer chooses the layout for a particular application of a car, to stabilize the car for that particular application is the only reason behind choosing that type of layout.

Stability in the massive object or car about an axis perpendicular toward the orientation of movement is referred to as directional stability. The term "vehicle stability" refers to a vehicle's proclivity to revert towards its appropriate orientation in connection to an approaching medium while rotated from that initial position (Directional stability, n.d.).

3.1 Front Wheel Drive

3.1.1 Front–Engine

Combining all of these aspects of the power generator, transmission, clutch, and final drive into a single unit on the other hand, most power generators, a horizontal power generator setup is in the conventional direction is used. This power generator can be mounted either longitudinally or rotatably. It looks like the front axle's weight distribution is much more than 50 percent, if you count only what is on the axle closest to the driver's seat (Passenger Car Layouts, 2010).

Advantages:

- Because of the inclusion of the power generator, transmission, clutch, and final drive through the front, this design, this has a greater ability to attain top speed (When contrasted with a tail engine , front-wheel drive, that does not happen).
- Greater traveller’s room is present because the propeller shaft is removed.
- These tires have the tendency to understeer, which means they are more forgiving when it comes to oversteer (assuming the reality that the average car driver and no traction-stability control, understeer is simpler to notice and accurate).
- It is the most affordable, lightest, and compact option.
- **Disadvantages:**
- When climbing a hill, traction is lost as weight shifts backwards.
- Inefficient braking, when braking aggressively, it is really easy to lock up the back wheels, it is as if the driver only have two wheels to decelerate with, despite the fact that they all have a good extent of control, despite the weight moves to the front.
- The steering radius is decreased as a result of the drive shafts. Almost, all of the work must be done by front wheels (accelerate, decelerate, handling).
- This type of layout is used by most of the manufacturers like, Ford, Audi, Volkswagen, Toyota and more (Passenger Car Layouts, 2010).

3.2 Rear Wheel Drive

3.2.1 Front–Engine

Normally, the power generator is longitudinal. Clutch and gearbox can be mounted directly to the power generator or to the rear alongside the differential, which improves weight distribution.

Advantages:

- Enhances weight distribution; a vehicle with just a 50-50 distribution of weight controls quite tactfully than one with a heavier weight distribution on one axel.
- Excellent grip when accelerating as well as deceleration.
- More Secure in a front accident, there are fewer systems on the front line, which means fewer risks on interference.
- While moving up a steep incline road, the weight moves towards rear end, which enhances the grip.
- Simpler to construct the connections within the thrust system.
- Since there are fewer material beneath the bonnet, larger power generators can be mounted.
- Repair Work is also simpler owing to the reality that it is more accessible.
- Because driving and steering are accomplished via distinct axels, wear is more evenly distributed among the wheels in every drive shaft.

Disadvantages:

- It lowers rear-seat leg space, a tunnel is necessary for propeller-driven shaft.
- It shrinks the boot space for luggage.
- Heavier as well as much more expensive.
- If the vehicle gets trapped in the mud or snowfall, it will be harder to drive down quickly than it is with a front-wheel-drive vehicle.

- This type of layout is used by manufacturers like BMW, Benz, and many more (Passenger Car Layouts, 2010).

3.2.2 Rear–Engine

The power generator, clutch, and transmission are all located at the rear end. And as a consequence, the boot space is consumed. In this configuration, the back axle bears over 50percent of overall of the weight. Propeller-driven shaft is totally unnecessary. The clutch, drivetrain, power generator, and final transmission are all incorporated into a single entity.

Advantages:

- Weight distribution towards the rear improves acceleration and slowing, the back axles as well as disc brakes could be designed to support more breaking force due to rear end's weight distribution.
- While climbing hills, excellent traction is available.
- There is more passenger space available for a particular body length.
- The power generator and drivetrain assembly is extremely compact and easily accessible.
- Travellers are kept comfy, thanks to the lack of power generator noise, high temperatures, but also car exhaust.
- Front-side of automobile gives better visibility, and the aerodynamic overall shape provides excellent streaming lining.

Disadvantages:

- At high speeds, a car with relatively high weight distribution on the back wheel would become unstable. The vehicle has a higher tendency to oversteer.
- Front space must be decreased to accommodate the front wheel's steering lock.
- Power generator compartment space is squandered.
- Complications with power generator cooling system's configuration. Natural radiator cooling is indeed not feasible. Power consumption increases. Servicing is made more difficult by the compressed power generator, clutch, but also powertrain.
- The wheels turn quite steeply as a result, the vehicle's tendency to oversteer. This requires the driver to steer the car in the reverse direction to affect the correction.
- Loss of the boot space for luggage.
- Loss of behind passenger occupancy.
- The gasoline tank is normally positioned on the front lines, which constitutes a security risk during a crash.
- When accelerating from a standstill at full throttle in a sporty car, steering control is mostly completely missed.
- Overwhelming majority of the race cars like Porsche 911, and Fiat 500/850 Coupe, Chevy Corvair and so many (Passenger Car Layouts, 2010) (Patil, 2016).

3.2.3 Mid–Engine

This power generator layout positions the power generator among both the axles and drives the rear axles. The mass allocation is normally 50-50.

Advantages:

- Excellent acceleration due to weight transfer to the back side.
- Braking efficiency.
- Handling is neutral.

Disadvantages:

- Acceleration results in loss of steering.
- Requires additional space for boot.
- Here are no rear seats.
- There are issues with cooling system.
- Ferrari F430, Porsche Cayman are the cars uses this layout and many more (Passenger Car Layouts, 2010).

3.3 Four Wheel Drive

3.3.1 Front–Engine

The power generator forces all axles of the car in this configuration, making the entire vehicle's weight easily accessible for traction. It has similar characteristics as Rear Wheel Drive–Front Engine layout.

Advantages:

- Better handling of the car.
- Enhanced acceleration of the car.

Disadvantages:

- In contrast to front engine layouts, it adds weight and cost of manufacturing.
- There is a decrease of chamber in the rear seats' leg room.
- Subaru Impreza, Mitsubishi Lancer and many more cars are using this layout (Passenger Car Layouts, 2010).

There are several factors affecting automobile handling along with driving steadiness, including vehicle speed, the vehicle's lateral forces, the vehicle's center of gravity position, the cornering characteristics of the rubber tires, the stiffness of the steering system, steering transmission ratio, and the vertical direction of inertial moments (Guo, Guo, Zhang, & Wang).

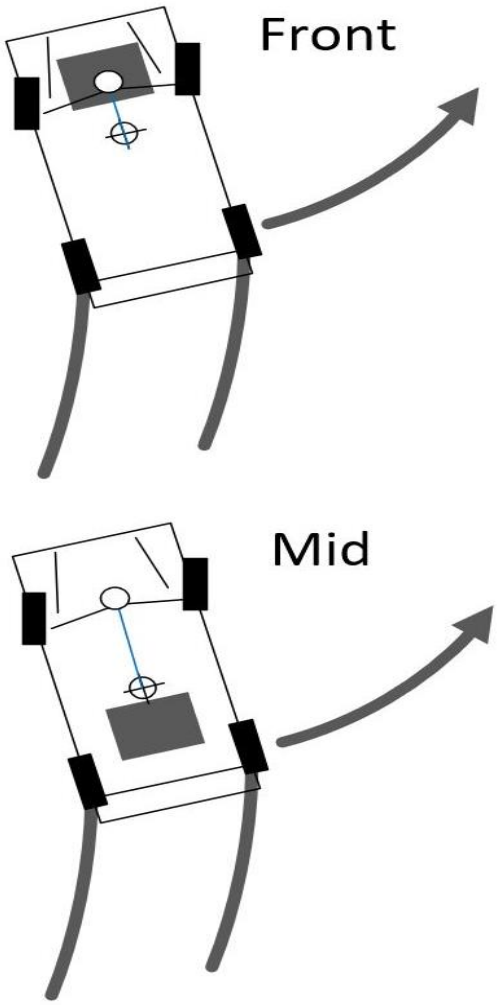

Figure 13: Oversteer of the vehicle due to stability (Diagram Database).

ISSN No:-2456-2165

IV. CONCLUSION

In this paper the study of automobile layouts and their stability is completed. The stability of an automobile is a considerable element in the design and development process for every design engineer. Stability makes the automobile, to move in the particular or desired direction, safely.

From the above types of layouts, the most stable layout with better performance is the only, four Wheel Drive–Front Engine layout, it is almost similar to Rear Wheel Drive–Front Engine layout, which has more weight distribution among all the layouts. Since, the power generator and transmission are at the front side, the propeller shaft, center differential are placed in the middle, and the rear differential, gasoline tank are at the rear side of the automobile, so the weight is distributed evenly. But its cost of production is more than compared to others, it can be reduced by using unconventional manufacturing methods.

The next layout which is less stability than four Wheel drive–Front engine, is Rear wheel drive–Front engine. Because this layout is less weight than the four Wheel drive–Front engine.

The next stable layout is that Rear wheel drive–Mid engine. Since it has 50-50percent of weight distribution. But the only problem is that the back seats are absent. Mostly race cars and some coupes uses this type of layout.

The least stable layouts are Front wheel drive–Front Engine and Rear wheel drive–Rear engine. Since majority of the weight is only concentrates at the power generator side and the weight allocation is not even, either one of the axles will be having more load on them. So, braking or acceleration for those layouts will be not easy. But the only advantage is that their cost of production is less.

Selecting any layout for a car and making adjustments to the camber, toe angle, and caster of wheels, the contact points of both the wheels and tires with the road are improved, that also ultimately enhances the car's stability whether it is traveling straight or through a bend, lowering the center of gravity of the car, using spoilers, wheel alignment, weight reduction, better suspension systems can also show awesome results (8 Effective Ways to Improve Your Car’s Handling, 2016).

REFERENCES

[1]. *8 Effective Ways to Improve Your Car's Handling*. (2016, 06 16). (Car Some) Retrieved from https://www.carsomesg.com/news/item/8-Effective-Ways-to-Improve-Your-Cars-Handling
[2]. *Build your own race car.* (n.d.). Retrieved from https://www.buildyourownracecar.com/race-car-powertrain-basics-and-design/2/
[3]. *Car*. (n.d.). (Wikipedia) Retrieved 05 01, 2021, from https://en.wikipedia.org/wiki/Car
[4]. *Car Layout*. (n.d.). (Wikipedia) Retrieved from https://en.wikipedia.org/wiki/Car_layout
[5]. *Diagram Database.* (n.d.). Retrieved from http://device-lot.sirtarghe.it/device-lot-wiring/rear-engine-diagram
[6]. *Directional stability*. (n.d.). (Wikipedia) Retrieved from https://en.wikipedia.org/wiki/Directional_stability#:~:text=Directional%20stability%20is%20stability%20of,%2C%20road%20surface%2C%20etc.)
[7]. Guo, X., Guo, W., Zhang, H., & Wang, Q. (n.d.). Analysis of Operating Vehicle Handling and Driving Stability Impact Elements. *Springer link.*
[8]. Muscoplat, R. (2018, 06 08). *Ricks free auto repair advice.* Retrieved from https://ricksfreeautorepairadvice.com/how-all-wheel-drive-works/
[9]. *Passenger Car Layouts*. (2010, 02 04). (Petrol Smell) Retrieved 05 05, 2021, from http://petrolsmell.com/2010/02/04/passenger-car-layouts/#google_vignette
[10]. Patil, S. (2016, 02 04). *Types of Automobile Layouts*. (Wordpress) Retrieved from https://sagarpatil860.wordpress.com/2016/02/04/types-of-automobile-layout/
[11]. Photo, A. S. (2017, 10 29). *Alamy*. Retrieved from https://www.alamy.com/car-transmission-system-layout-image227467032.html