UNIT – I INTRODUCTION

1.1 INTRODUCTION:

A hybrid vehicle combines any two power (energy) sources. Possible combinations include diesel/electric, gasoline/fly wheel, and fuel cell (FC)/battery. Typically, one energy source is storage, and the other is conversion of a fuel to energy. The combination of two power sources may support two separate propulsion systems. Thus to be a True hybrid, the vehicle must have at least two modes of propulsion. For example, a truck that uses a diesel to drive a generator, which in turn drives several electrical motors for all-wheel drive, is *not a hybrid*. But if the truck has electrical energy storage to provide a second mode, which is electrical assists, then it is a hybrid Vehicle. These two power sources may be paired in series, meaning that the gas engine charges the batteries of an electric motor that powers the car, or in parallel, with both mechanisms driving the car directly.

CONVENTIONAL VEHICLES:

A conventional engine-driven vehicle uses its engine to translate fuel energy into shaft power, directing most of this power through the drive train to turn the wheels. Much of the heat generated by combustion cannot be used for work and is wasted, both because heat engines have theoretical efficiency limit. Moreover, it is impossible to reach the theoretical efficiency limit because:

- Some heat is lost through cylinder walls before it can do work

- Some fuel is burned at less than the highest possible pressure

• Fuel is also burned while the engine is experiencing negative load (during braking) or when the vehicle is coasting or at a stop, with the engine idling.

1.2 BASIC VEHICLE PERFORMANCE:

The performance of a vehicle is usually described by its maximum cruising speed, grade ability, and acceleration. The predication of vehicle performances based on the relationship between tractive effort and vehicle speed discussed in Sections 2.5 and 2.6. For on-road vehicles, it is assumed that the maximum tractive effort is limited by the maximum torque of the power plant rather than the road adhesion capability.

1.1.1. General Description of Vehicle Movement

The Figure shows the forces acting on a vehicle moving up a grade. The tractive effort, *Ft*, in the contact area between tires of the driven wheels and the road surface propels the vehicle forward. It is produced by the power plant torque and is transferred through transmission and final drive to the drive wheels. While the vehicle is moving, there is resistance that tries to stop its movement. The resistance usually includes tire rolling resistance, aerodynamic drag, and uphill resistance. According to Newton's second law, vehicle acceleration can be written as where V is vehicle speed, ΣFtr is the total tractive effort of the vehicle, ΣFtr is the total resistance, $Mv$is the total mass of the vehicle, and δ is the mass factor, which is an effect of rotating components in the power train. Equation.

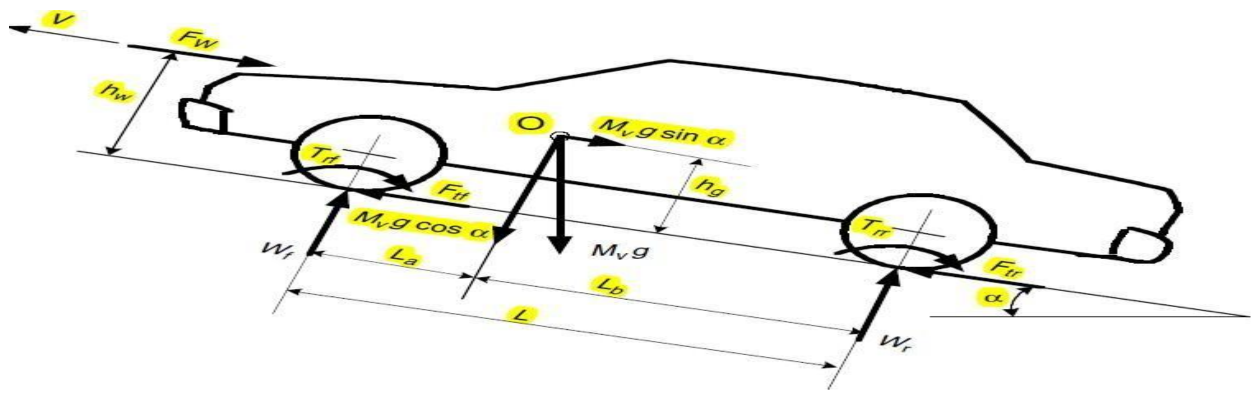

Figure 1.1 Forces acting on a vehicle

The above fig indicates that speed and acceleration depend on tractive effort, resistance, And vehicle mass.

Vehicle Resistance

As shown in Figure 1.1, vehicle resistance opposing its movement includes rolling resistance of the tires, appearing in Figure 1.1 as rolling resistance torque *Trf* and *Trr*, aerodynamic drag, *Fw*, and grading resistance (the term *Mv g* sin α in Figure). All of the resistances will be discussed in detail in the following sections.

Rolling Resistance

The rolling resistance of tires on hard surfaces is primarily caused by hysteresis in the tire materials. This is due to the deflection of the carcass while the tire is rolling. The hysteresis causes an asymmetric distribution of ground reaction forces. The pressure in the leading half of the contact area is larger than that in the trailing half, as shown in Figure1.1 (a).This phenomenon results in the ground reaction force shifting forward. This forwardly shifted ground reaction force, with the normal load acting on the wheel center, Creates a moment that opposes the rolling of the wheel. On soft surfaces, the rolling resistance is primarily caused by deformation of the ground surface as shown in Figure 1.5.1.1(b). The ground reaction force almost completely Shifts to the leading half.

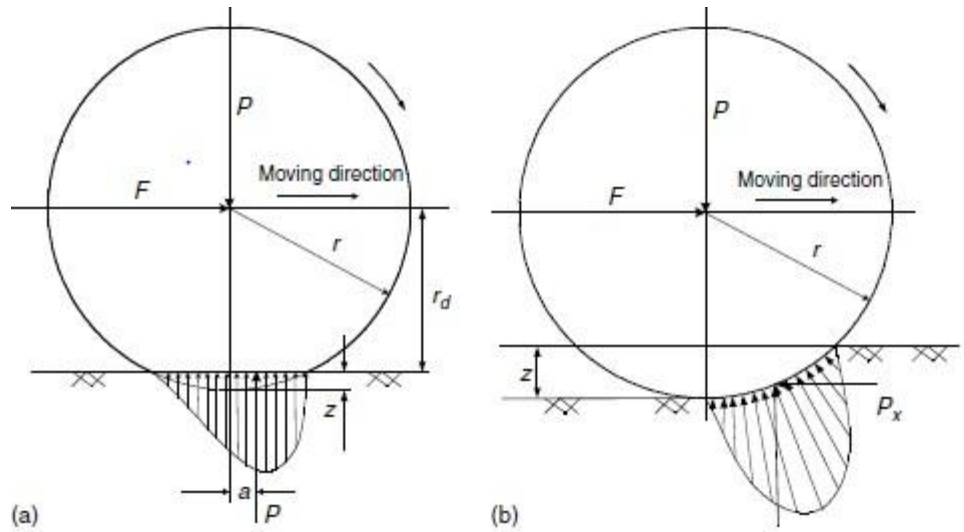

Figure 1.2(a)&(b): Tire deflection and rolling resistance on a (a) hard and (b) soft road surface

The moment produced by the forward shift of the resultant ground reaction force is called the rolling resistant moment, as shown in Figure 1.5.1.1(a),and can be expressed as

$$T_r = Pa. \qquad \text{..................eq.1}$$

To keep the wheel rolling, a force *F*, acting on the center of the wheels, is required to balance this rolling resistant moment. This force is expressed as

$$F = \frac{T_r}{r_d} = \frac{Pa}{r_d} = Pf_r, \qquad \text{...........................eq.2}$$

Where *rd* is the effective radius of the tire and *fr*= *a/rd*is called the rolling resistance coefficient. In this way, the rolling resistant moment can be replaced equivalently by horizontal force acting on the wheel center in the opposite direction of the movement of the wheel. This equivalent force is called rolling resistance with a magnitude of

$$F_r = Pf_r, \qquad \text{……….. eq.3}$$

Where *P* is the normal load, acting on the center of the rolling wheel. When a vehicle is operated on a slope
road, the normal load, *P*, should be replaced by the component, which is perpendicular to the road surface. That is

$$F_r = Pf_r \cos\alpha, \qquad \text{…………………. eq.4}$$

The rolling resistance coefficient, *fr*, is a function of the tire material, tire structure, tire temperature, tire inflation pressure, tread geometry, road roughness, road material, and the presence or absence.
The rolling resistance coefficient of passenger cars on concrete road
may be calculated from the following equation:

$$f_r = f_0 + f_s\left(\frac{V}{100}\right)^{2.5}, \qquad \text{…………………. eq.5}$$

Where*V*is vehicle speed in km/h, and *f*0 and *fs* depend on
inflation pressure of the tire.1
In vehicle performance calculation, it is sufficient to consider the rolling resistance coefficient as a linear function of speed. For the most common range of inflation pressure, the following equation can be used for a passenger car on concrete road.

$$f_r = 0.01\left(1+\frac{V}{100}\right)$$ ……………… eq.6

This equation predicts the values of *fr* with acceptable accuracy for speeds upto128km/h.

1.5.1.2 Aerodynamic Drag:

A vehicle traveling at a particular speed in air encounters a force resisting its motion. This force is referred to as aerodynamic drag. It mainly results from two components: shape drag and skin friction.

Shape drag: The forward motion of the vehicle pushes the air in front of it. However, the air cannot instantaneously move out of the way and its pressures thus increased, resulting in high air pressure. In addition, the air behind the vehicle cannot instantaneously fill the space left by the forward Motion of the vehicle. This creates a zone of low air pressure. The motion has therefore created two zones of pressure that oppose the motion of a vehicle by pushing it forward (high pressure in front) and pulling it backward (low-pressure in the back) as shown in Figure. The resulting force on the vehicle is the shape drag.3

Skin friction: Air close to the skin of the vehicle moves almost at the speed of the vehicle while air far from the vehicle remains still.

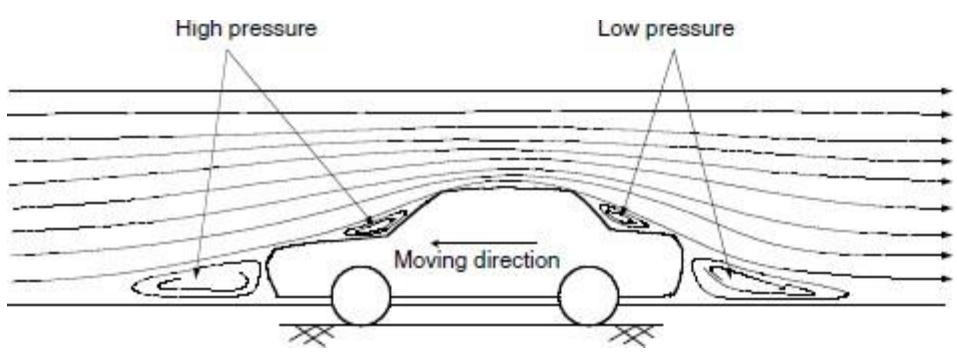

Figure 1.3 Shapedrag

Molecules move at a wide range of speeds. The difference in speed between two air molecules produces a friction that results in the second component of aerodynamic drag. Aerodynamic drag is a function of vehicle speed *V*, vehicle frontal area *Af*, shape of the vehicle, and air density ρ. Aerodynamic drag is expressed as

$$F_w = \frac{1}{2}\rho A_f C_D (V+V_w)^2, \qquad \text{.....................................eq7}$$

where *CD* is the aerodynamic drag coefficient that characterizes the shape of the vehicle and *Vw* is the component of wind speed on the vehicle's moving direction, which has a positive sign when this component is opposite to the vehicle speed and a negative sign when it is in the same direction as vehicle speed. The aerodynamic drag coefficients for a few types of vehicle body shapes are shown in Figure1.3.

1.3 Grading Resistance

When a vehicle goes up or down a slope, its weight produces a component, which is always directed to the downward direction, as shown in Figure This component either opposes the forward motion (grade climbing) or helps the forward motion (grade descending). In vehicle performance analysis, on uphill operation is considered. This grading force is usually called grading resistance.

Vehicle Type	Coefficient of Aerodymanic Resistance
Open convertible	0.5–0.7
Van body	0.5–0.7
Ponton body	0.4–0.55
Wedge-shaped body; headlamps and bumpers are integrated into the body, covered underbody, optimized cooling air flow	0.3–0.4
Headlamp and all wheels in body, covered underbody	0.2–0.25
K-shaped (small breakway section)	0.23
Optimum streamlined design	0.15–0.20
Trucks, road trains	0.8–1.5
Buses	0.6–0.7
Streamlined buses	0.3–0.4
Motorcycles	0.6–0.7

Figure1.4 Indicative drag coefficients for different body shapes

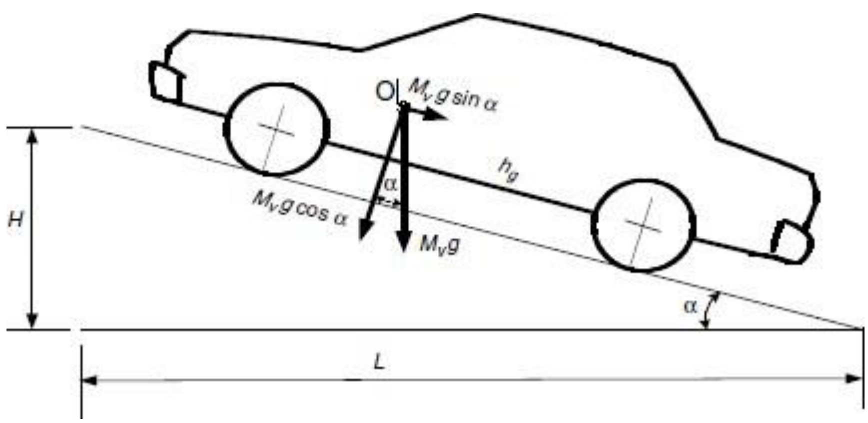

Figure 1.5 Automobile climbing a grade

The grading resistance, from Figure 1.5, can be expressed as

$$F_g = M_v g \sin\alpha. \qquad \text{...........eq8}$$

To simplify the calculation, the road angle, α, is usually replaced by grade value when the road angle is small. As shown in Figure 1.5.1.3, the grade is defined as

$$i = \frac{H}{L} = \tan\alpha \approx \sin\alpha. \qquad \text{...........eq9}$$

In some literature, the tire rolling resistance and grading resistance together are called road resistance, which is expressed as

$$F_{rd} = F_f + F_g = M_v g(f_r \cos\alpha + \sin\alpha). \qquad \text{...............eq10}$$

When the road angle is small, the road resistance can be simplified as

$$F_{rd} = F_f + F_g = M_v g(f_r + i).$$