INFLUENCE OF GEAR RATIO PATTERN ON VEHICLE PERFORMANCE

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DECLARATION

"I hereby declare that this report that title 'Influence of Gear Ratio Pattern on Vehicle Performance' is the result of my own work except for quotes as cited in the references."

Signature :.....

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Date :.....

SUPERVISOR DECLARATION

"I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering"

Signature	: .....
Name of supervisor	: En. Adzni bin Md Saad
Date	: .....

DEDICATION

Dedicated to my beloved family, supervisor, all the lecturer and also my friend which always be on my side

ABSTRACT

In modern vehicle design, transmission is a crucial component that functions to deliver power and torque from engine to wheel so the vehicle can move based on desired speed. In general, 5 speed manual transmission consists of 5 sets of gear ratio with one set of final drive. It multiplies the torque produced by engine for each gear ratio in each shifts. This study concentrates on the effect of power output of transmission through different specifications of gear ratio to vehicle speed and acceleration. It involves the determination of total vehicle traction force as initial step and follows by obtaining the vehicle velocity by utilizing Newton Second Law. The transmission shifting procedure by using different sets of gear ratio is modelled by using Matlab Simulink software. The testing process is only carried out by using mathematical model simulation approach without any experimental works. The study on the effect on vehicle performance is only focusing on vehicle the top speed and acceleration (0 – 110 km/h). From the simulation results, vehicle performance can be analyzed and comparison is made between the results of different sets of gear ratio. The torque produces from custom 2 specification of gear ratio is higher than the standard version because of the closer range of gear ratio compare to others parameter. This custom 2 specification also produces better acceleration of 0 to 110km/h in just 8.8 seconds, as compared to standard version which clocks 14.4 seconds. In conclusion, this study shows that gear ratio influences the vehicle performance especially in terms of acceleration and top speed.

ABSTRAK

Dalam rekaan kenderaan masakini, transmisi merupakan komponen yang penting kerana ianya berfungsi sebagai penyambung kuasa dan tork dari enjin ke roda supaya kenderaan boleh bergerak berdasarkan kelajuan yang dikehendaki. Secara umum, dalam transmisi manual 5 kelajuan ianya meliputi 5 set nisbah gear dengan satu set pemacu akhir. Ia akan mengandakan tork yang dihasilkan dari enjin dengan menggunakan perbezaan setiap gear dalam setiap peralihan. Kajian ini menumpukan kepada kesan terhadap kuasa yang dikeluarkan melalui spesifikasi nisbah gear yang berbeza kepada pecutan dan kelajuan kenderaan. Ia melibatkan penentuan jumlah daya tarikan kenderaan sebagai langkah awal dan ianya diikuti dengan mendapatkan halaju kenderaan dengan menggunakan Hukum Kedua Newton. Prosedur peralihan dalam transmisi terhadap perbezaan nisbah gear akan dimodelkan mengunakan perisian Matlab Simulink. Proses ujian hanya dijalankan dengan menggunakan pendekatan simulasi model matematik tanpa melibatkan sebarang kerja eksperiman. Corak nisbah gear baru akan diperkenalkan dan ujian menggunakan model simulasi dibuat. Kajian mengenai kesan prestasi kenderaan hanya difokuskan pada kelajuan tertinggi dan juga pecutan (0 km/h - 110 km/h) sahaja. Dari simulasi tersebut, ia akan memberikan hasil dan perbandingan akan dibuat supaya kesan pada prestasi kenderaan dapat dianalisis. Keputusan menunjukkan bahawa nisbah gear penghantaran memberi kesan kepada prestasi kenderaan. Tork yang dihasilkan daripada nisbah gear spesifikasi custom 2 adalah lebih tinggi daripada versi standard (1.5 3sz-ve) kerana nisbah gear yang lebih dekat berbanding parameter lain. Spesifikasi custom 2 juga menghasilkan daya pecutan yang lebih baik dari 0km/h hingga 110km/h kerana hanya memerlukan 8.8 saat, berbanding versi standard hanya mencatatkan 14.4 saat sahaja. Kesimpulannya, kajian ini menunjukkan bahawa nisbah gear mempengaruhi prestasi kenderaan terutamanya dari segi pecutan dan kelajuan tertinggi.

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m	-	Mass
t	-	Time
C_d	-	Drag coefficient
A	-	Frontal area of object
a	-	Acceleration on bodies
F	-	Force on body
vf	-	Final velocity
vi	-	Initial Velocity
Δv	-	Change of velocity
V	-	Relative velocity of object
R_T	-	Rolling resistance
R_G	-	Gradient resistance
R_A	-	Aerodynamic resistance
R	-	Total road load / tractive force
$\emptyset$	-	Gradient of the hill being climbed (degree)
ρ	-	Air density
C_{rf}	-	Coefficient of rolling resistances
n_t	-	Transmission efficiency
n_a	-	Efficiency of final drive
i_a	-	Final drive ratio
i_t	-	Transmission gear ratio
Tw	-	Torque at the wheel

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 Background

This chapter is generally about the manual transmission and gear ratio. Transmission is a sub-system of the drive train with the exception of clutch and drive shaft. The transmission is connected to the engine through the clutch. The input shaft of the transmission therefore turns at the same rpm as the engine. There are two basic types of transmission that is manual and automatic. Manual transmission is shifted manually in each gear, while automatic transmission shifts between gears automatically, with no help from the driver. To understand the basic idea behind a standard transmission, Figure 1.1 shows a very simple five-speed transmission. The basic function of any type of automotive transmission is to transfer the engine torque to the vehicle with the desired ratio smoothly and efficiently. The most common control devices inside the transmission are clutches and hydraulic pistons. (Zongxuan.S, et al, 2005).

The choice of transmission units for a particular vehicle is usually influenced by what is in production and available in the market. The position of powertrain components within the vehicles has implications both for the engineering of the vehicle and the driveline components including transmission itself. The choice of vehicle layout is determined principally by the target market sector and brand image that the vehicle is required. The vehicle layout must also be sufficiently flexible to accommodate different engines.

From there, it is very important to appreciate the choice of gear ratio in a transmission as often dictated in practice by what is available or in mass production. This situation happens because of the large expenses involved in engineering new gear set, installing or modifying the manufacturing plant in order to make new parts. There are some cases that do necessitate a change, for example from petrol to diesel or a significant change to the weight of the vehicles in which the gearbox is to be installed. (Julian.H.S, 2002)

In this modern era, there has no need for experimental work involved in study of performance output from powertrain systems. It is a common practice to use analytical

models in prediction and assessment of new types of powertrain systems in automotive industry. (M.Kulkarni, et al, 2006). Matlab Simulink software is one of the software that can produce analytical model simulation to get the results of vehicle power performance by designing and calculating the gear ratio. Matlab is a language of technical computing and Simulink is simulation and model based design.

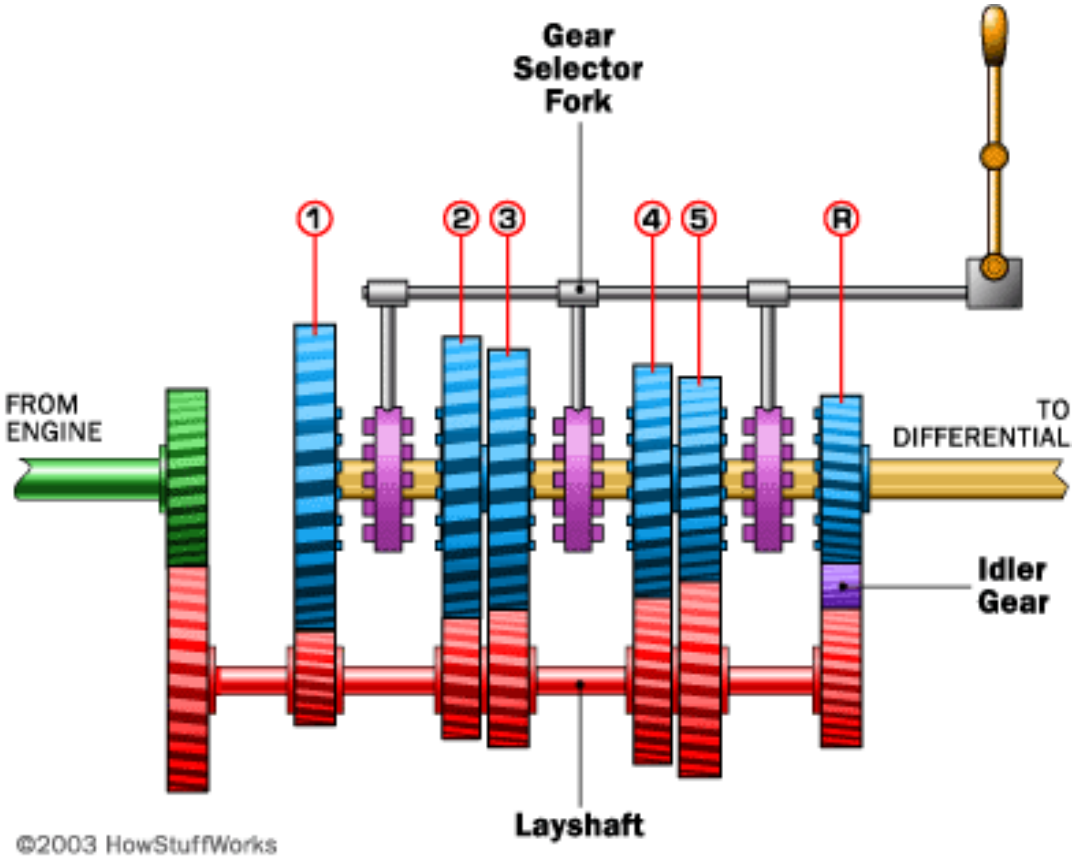

Figure 1.1: Schematic of basic 5-speed transmission (M.Brain, 2017)

1.2 Problem Statement

The aim of this project to analyze the optimum gear ratio parameters for vehicle output power. This project is focusing on the gear ratio output of manual transmission model based on the selected power input that had been chosen. In order to achieve the optimum torque and power, it needs to find the suitable gear ratio for the output performance of the vehicles by creating mathematical model simulation by using Matlab Simulink software. From the simulation process, it produces line graphs that

able to simulate the effect of various gear ratio by varying the values of drive and driven gears in each gearing set of transmission.

1.3 Objective

The objectives of this project are as follows:

1. To develop mathematical simulation model of vehicle transmission
2. To investigate the effects of gear ratio on vehicle performance

1.4 Scope of Project

The scopes of this project are:

1. Investigate gear ratio based on mathematical model simulation without any experimental work involved
2. Determination of optimum gear ratio is based on required vehicle performance and engine output.

CHAPTER 2

LITERATURE REVIEW

2.1 Vehicle Transmission

In general, the function and purpose of the transmission are to provide the operator with the option of maneuvering the vehicle in either the forward or reverse direction. This is the basic requirement of all automotive vehicles. Almost all vehicles have multiple forward gear ratios, but in most cases, only one ratio is provided for reverse. Another purpose of the transmission is to provide the operator with a selection of gear ratios between engine and wheel so that the vehicle can be operated at the best efficiency under a variety of operating conditions and loads. (David.L.H, 2016)

2.1.1 Introduction of vehicle transmission system

Transmission is used to describe a unit in driveline. The driveline includes all the components from the rod wheel until the output of the engine. The engine in vehicle creates rotational power and to move the car, it needs to transfer that rotational power to the wheels. The transmission provides this function in the drivetrain (Brett, 2017). Transmission is also called a gearbox. This study is only concentrating on manual gearbox. Manual transmission means that the driver needs to change the gear ratio setting by its own that parallel to vehicle speed.

The function of transmission is to perform several functions that affecting the vehicle. First of all, it can allow the vehicle to start from rest until it reach its desired velocity. It produces high engine revolutions due to low torque and power at low engine speed. Then, the transmission can help with the climbing ability. When driving through hill which has steep gradient, the movement of vehicles becomes difficult to overcome the resistance. So, it leads to the engine slowing down and hard to reach the top of the hill. Then, the gearbox helps by increasing the output torque to move the car or to climb the steep gradient of the road. Without the presence of transmission, the vehicle is not

having the neutral position and continuously moving. Gearbox can also move the vehicle backward if the reverse gear has been selected. The mechanism shows by stopping the rotating main shaft by the connection to the shift level and rotates the cam plates. Then, the vehicle moves reversely with the help of gearbox. Figure 2.1 below show the components in manual transmission.

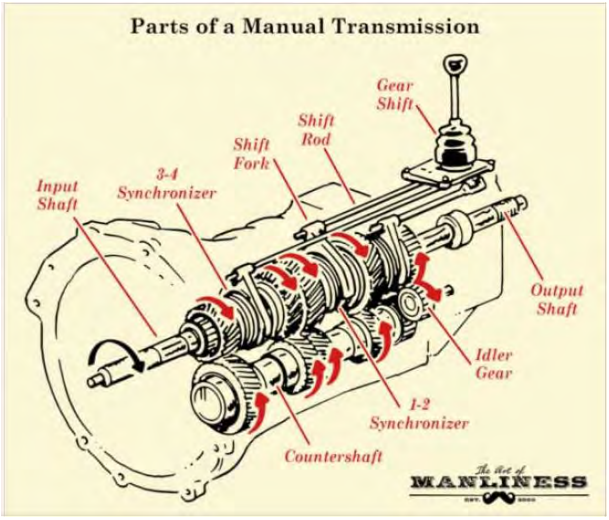

Figure 2.1: Components in manual transmission. (Brett, 2017).

2.2 Manual Transmission

The five-speed manual transmission is fairly standard on cars today.

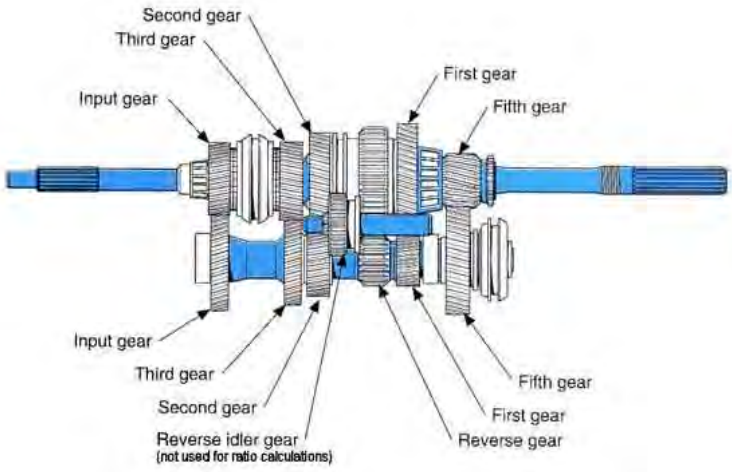

Figure 2.2: Layout of 5-speed transmission.

Based on the Figure 2.2 above, five-speed transmission applies one of five different gear ratios to the input shaft to produce a different rpm values at the output shaft. Here are some typical gear ratios. By referring to Figure 2.3, it shows a single unit that connects between green shaft and green gear. The green shaft comes from the engine through clutch. Then, the yellow shaft called splined shaft, which spins if the wheel is spinning. It is because the splined shaft is directly connected between the drive shaft and the differential of the drive wheel of the car.

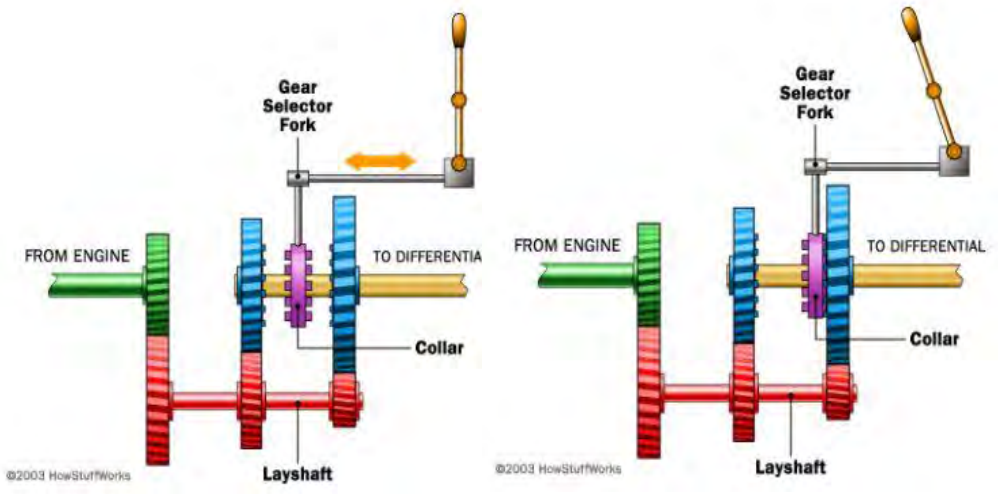

Figure 2.3: Schematic of changing for 1st gear. (M.Brain, 2017)

The red shaft is called as layshaft and all of the gears are connected as a single piece. Layshaft receives power directly from the engine when the clutch is engaged. The green and the redshaft are directly connected through their meshed gears. If the green shaft spinning, the red shaft will spin to. This is because all the gears on the layshaft and the green layshaft are spinning or moving as one unit.

The blue gears spinning on the yellow shaft because they rotate on the bearings. If the engine car is off but the car is moving, the blue and the layshaft are motionless because its movement are not directly connected to the engine. There is a collar that connects some part of the blue gear and the yellow drive shaft. The teeth on the collar are called dog teeth. The collar teeth fit into holes to engage layshaft with the blue gear. When the collar is connected, the blue gear will directly move the yellow shaft. The yellow shaft will engage either of the blue gear after the collar slide left or right along the yellow shaft. (M.Brain, 2017)

2.3 Gearing

These are the gears that are mounted on the output shaft by bearings and determine which “gear” is in the car. Each of these gears is constantly enmeshed with one of the gears on the countershaft and are constantly spinning. This constantly enmeshed arrangement is as in synchronized transmissions or constant mesh transmissions, which most modern vehicles use (Brett, 2017). The power flow from input to output of transmission for different gear ratio is shown in Figure 2.4 below.

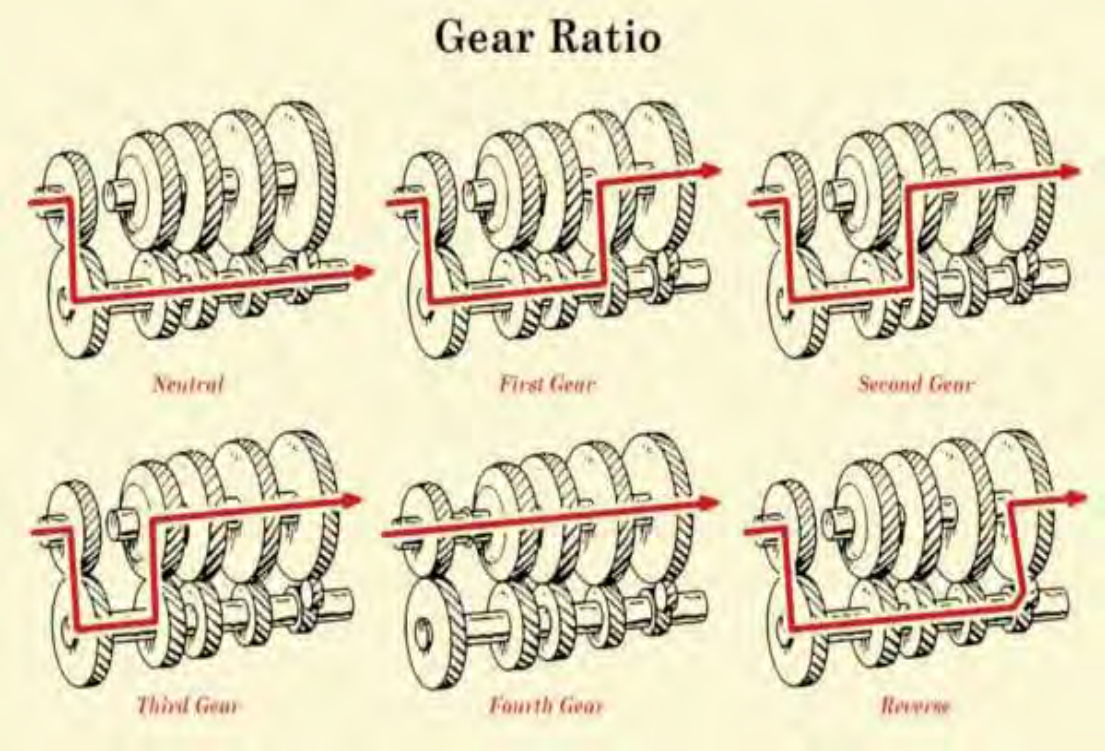

Figure 2.4 Five speed transmission power flow for all gearing

2.3.1 First gear

First gear is the largest gear, and the gears get progressively smaller as it gets to fifth gear. Because first gear is bigger than the countershaft gear that it is connected to, it can spin slower than the input shaft but deliver more power to the output shaft. When first gear is engaged, it only produces low speed, but high power is delivered. This gear ratio is great for starting the car from a standstill.

2.3.2 Second gear

The second gear is slightly smaller than the first gear, but still is enmeshed with a smaller gear. By changing to the second gears, the countershaft moves in reverse direction and leads to the same direction of rotation for output shaft as the input shaft. So, the second gear is locked to the output shaft due to the synchronizer that moves forward. Speed is increased and power decreasing slightly, which increasing the speed of the vehicle.

2.3.3 Third gear

Third gear is slightly smaller than the second, but still enmeshed with a smaller gear. The power flows are likely same with the previous gear but the synchronizer has moved to the rear and locked at the third/fourth gear.

2.3.4 Fourth gear

Fourth gear is slightly smaller than the third. In many vehicles, by the time a car is in fourth gear, the output shaft is moving at the same speed as the input shaft. This arrangement is called “direct drive”. It gives maximum output speed and promotes to the maximum fuel economy.

2.3.5 Fifth gear

The vehicle with fifth gear and also called “overdrive” is connected to a gear that is significantly larger. Fifth gear or overdrive gear is a top speed gear for overdrive to increase speed. This allows the fifth gear to spin much faster than the gear that delivers the power.

2.3.6 Reverse gear

Direction of transmission spins in the opposite rotation of the engine through small idler gear. Gear from the input and output are turning in the opposite direction of each other. The output shaft and synchronizer are locked together and direct powers

to the gears without affecting the gear ratio. Therefore, it is impossible to throw the transmission into reverse while the car is moving forward because the dog teeth are never engaged.

2.4 Gear Shifting

To produce maximum acceleration (torque), higher speeds (power) and good fuel economy, gear shifting is important to be taken into consideration in optimizing engine operation. It is used as an alternative way of the engine to operate at optimum efficiency by using shifting gear strategy (Kahlbau.S, et.al. 2013). Gear shifting strategy is a process that is required in order to increase the acceleration. The lower gears of the transmission are usually used for normal acceleration of the vehicle to achieve the desired cruising speed. The highest gear of the transmission is used to maintain the desired speed. The fifth gear is recommended for use in maintaining highway cruising speeds. The use of the fifth gear in city traffic is not recommended. Figure 2.5 shows the shifting pattern in normal 5-speed transmission.

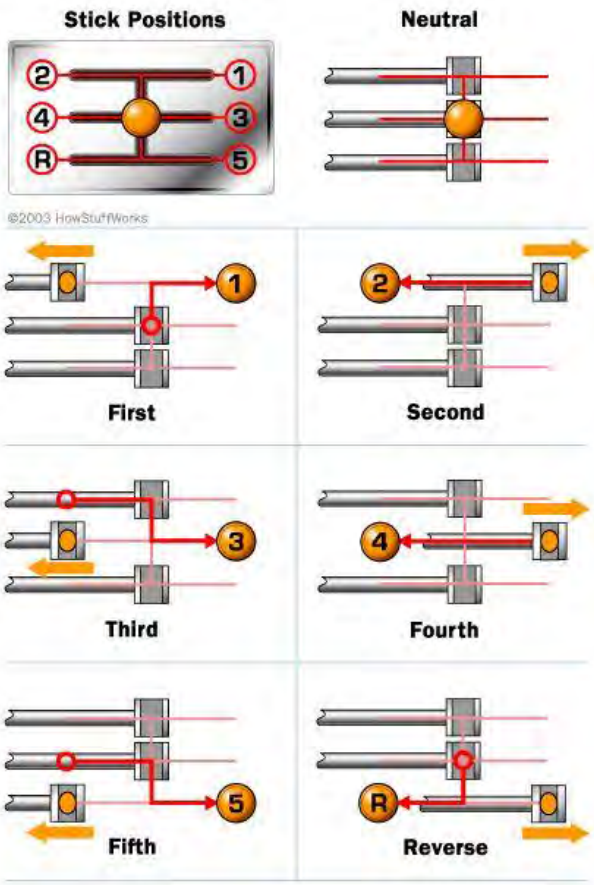

Figure 2.5: Shifting pattern in normal 5-speed transmission