Task 1

The performance of two sets of 5 speed manual transmission gear from different suppliers were tested and the transmission performance graphs were plotted for comparison. Few variables were considered which were shown in the graphs, such as running resistance (%), traction force (N), engine speed (rpm) and vehicle speed (kph). Black solid line indicates the running resistance which is the total resistance force determined by the aerodynamic, inertia, rolling and the slope of the road. The coloured solid line indicates the gear ratio. The coloured dotted line indicates the traction force for each gear ratio. The graphs were used to measure the climb ability, response at low/high vehicle speed and the fuel consumption. Besides, other factors were taken into consideration to choose the suitable transmission such as emission requirement, warranty and serviceability.

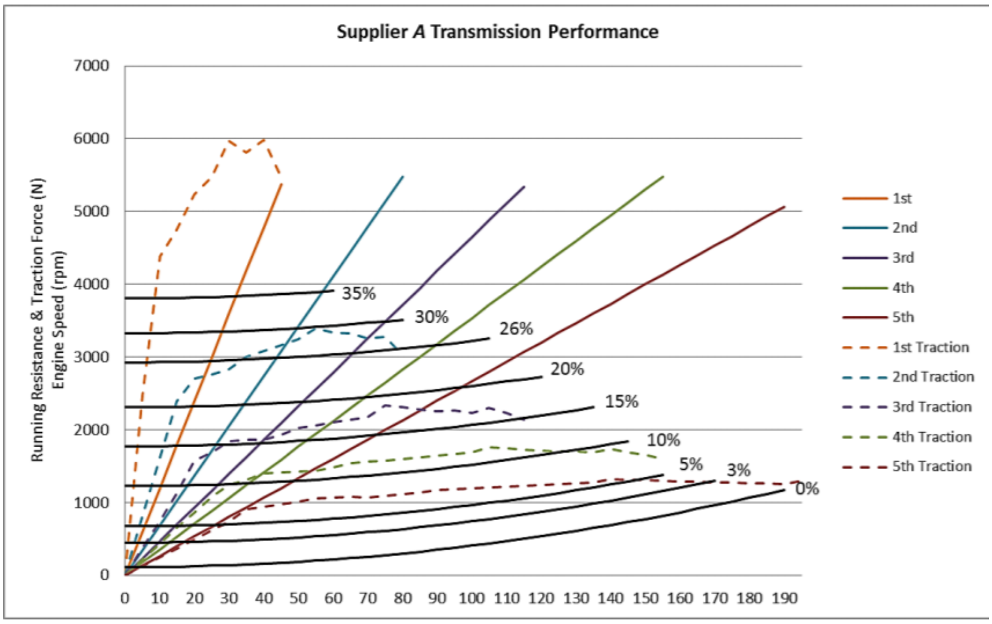


Figure 1: Supplier *A* transmission performance

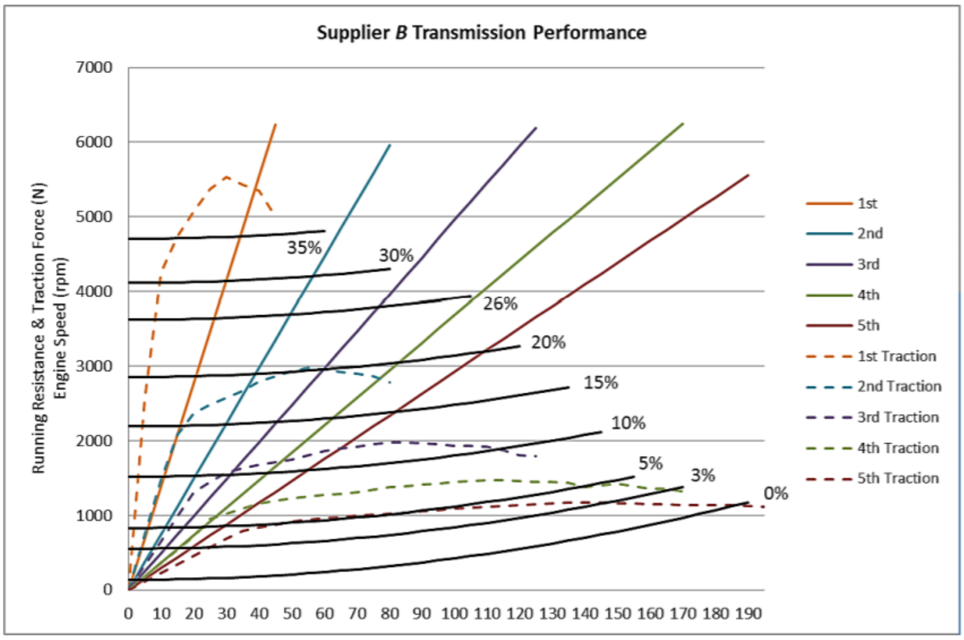


Figure 2: Supplier *B* transmission performance

For the supplier A transmission, the traction force generated by 2nd, 3rd, 4th and 5th gear can overcome the running resistance up to 26%, 15%, 10% and 5% respectively. For the supplier B transmission, the traction force generated by 3rd, 4th and 5th gear can overcome the running resistance up to 10%, 5% and 3% respectively. The 2nd gear traction force from supplier B can barely overcome the running resistance up to 20%. The 1st gear traction force from both suppliers can overcome the running resistance up to 35%, but the supplier A transmission has greater traction force as the gap between coloured dotted line and the black solid line is huge. Therefore, supplier A transmission has better climb ability.

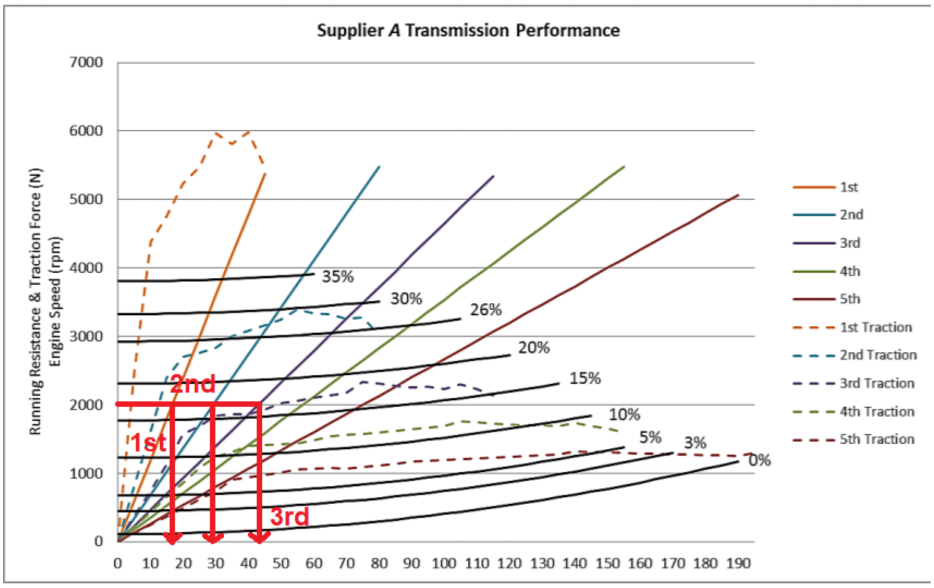


Figure 3: Supplier *A* transmission performance

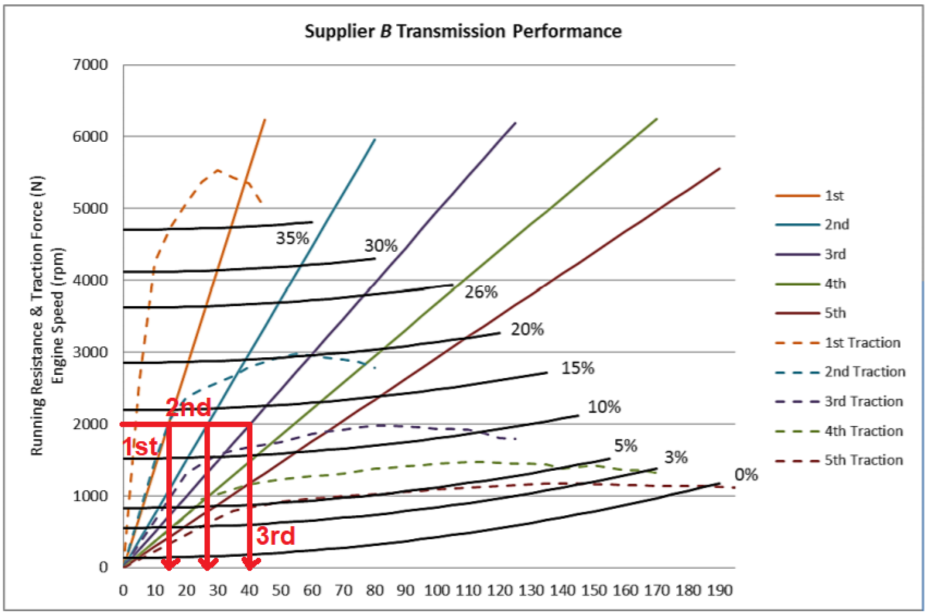


Figure 4: Supplier *B* transmission performance

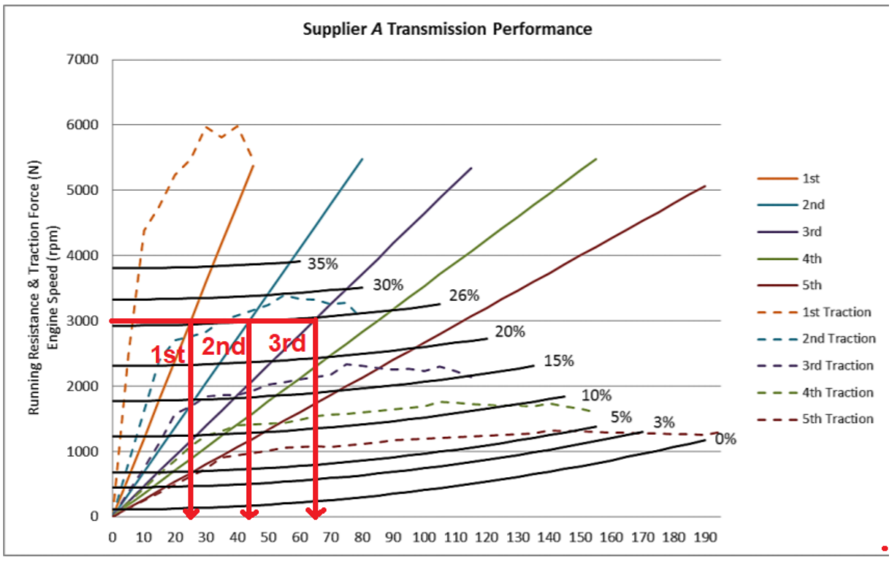


Figure **5**: Supplier *A* transmission performance

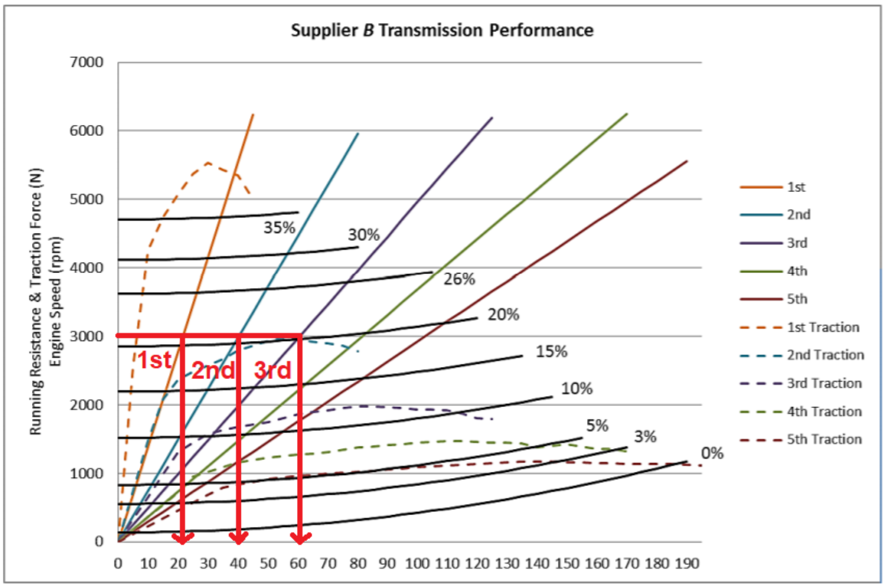


Figure **6** .: Supplier *B* transmission performance

With low vehicle speed, the transmission is usually stay on 1st, 2nd or 3rd gear, these gears were selected to observe. Engine speed of 2000 rpm and 3000 rpm were selected to observe how much vehicle speed could be produced. According to figure 3 and 5, when engine speed of supplier A transmission is at 2000 rpm, the vehicle speeds are 17kph, 29kph and 44kph at 1st, 2nd and 3rd gear respectively. When engine speed is at 3000 rpm, the vehicle speeds are 25kph, 43kph and 65kph at 1st, 2nd and 3rd gear respectively. According to figure 4 and 6, when engine speed of supplier B transmission is at 2000 rpm, the vehicle speeds are 14kph, 28kph and 40kph at 1st, 2nd and 3rd gear respectively. When it has engine speed of 3000 rpm, the vehicle speeds are 21kph, 40kph and 60kph at 1st, 2nd and 3rd gear respectively. Therefore, supplier A transmission has better response at low vehicle speed as it has higher vehicle speed at the same engine speed and gear ratio.

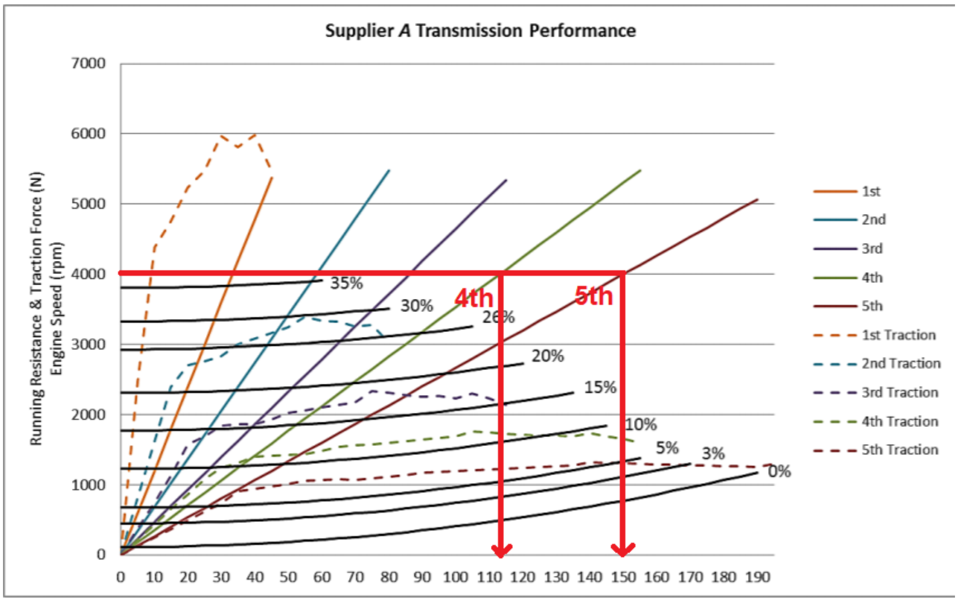


Figure 7: Supplier *A* transmission performance

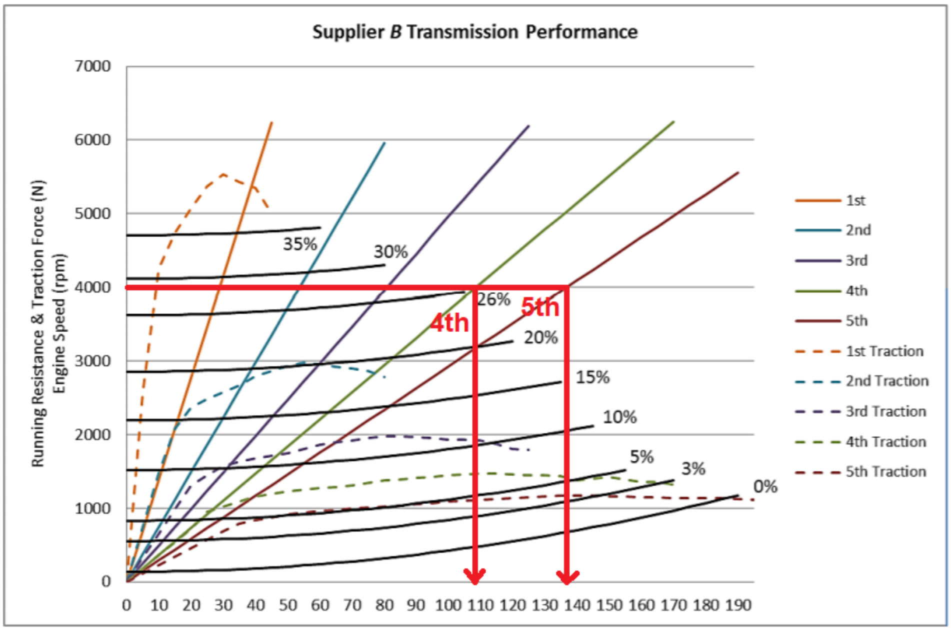


Figure 8 : Supplier *B* transmission performance

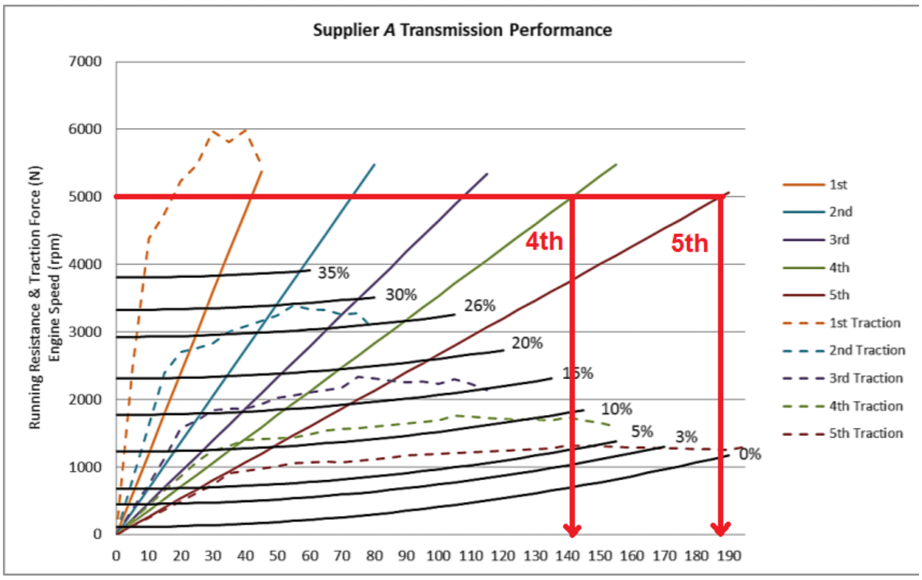


Figure 9: Supplier *A* transmission performance

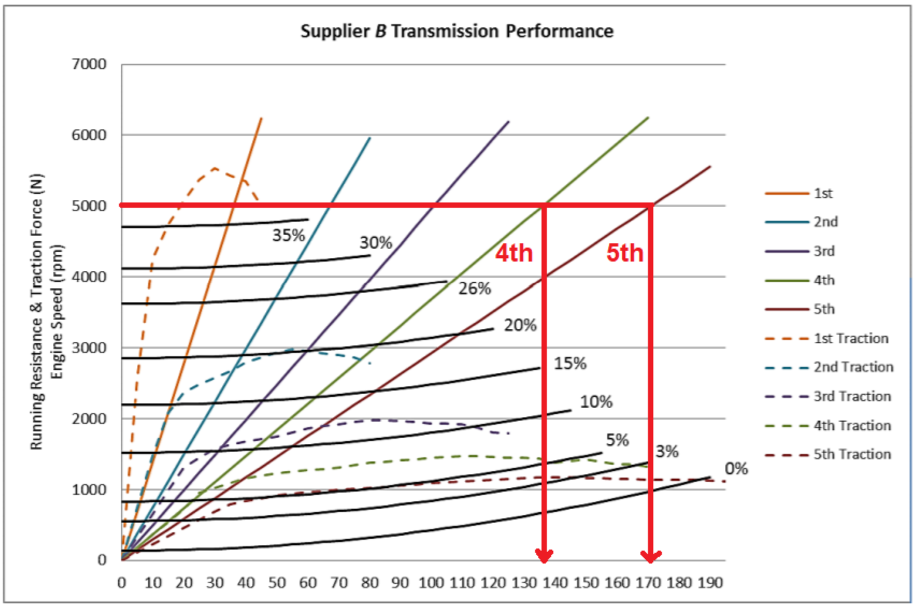


Figure 10: Supplier *B* transmission performance

In high vehicle speed, the transmission is usually stay on 4th and 5th gear, these gears were selected to observe. Engine speed of 4000 rpm and 5000 rpm were selected to observe how much vehicle speed could be produced. According to figure 7 and 9, when engine speed of supplier A transmission is at 4000 rpm, the vehicle speeds are 112kph and 150kph at 4th and 5th gear respectively. When the engine speed is at 5000 rpm, the vehicle speeds are 141kph and 188kph at 4th and 5th gear respectively. According to figure 8 and 10, when engine speed of supplier A transmission is at 4000 rpm, the vehicle speeds are 109kph and 137kph at 4th and 5th gear respectively. When the engine speed is at 5000 rpm, the vehicle speeds are 137kph and 170kph at 4th and 5th gear respectively. Therefore, supplier A transmission has better response at high vehicle speed as it has higher vehicle speed at the same engine speed and gear ratio.

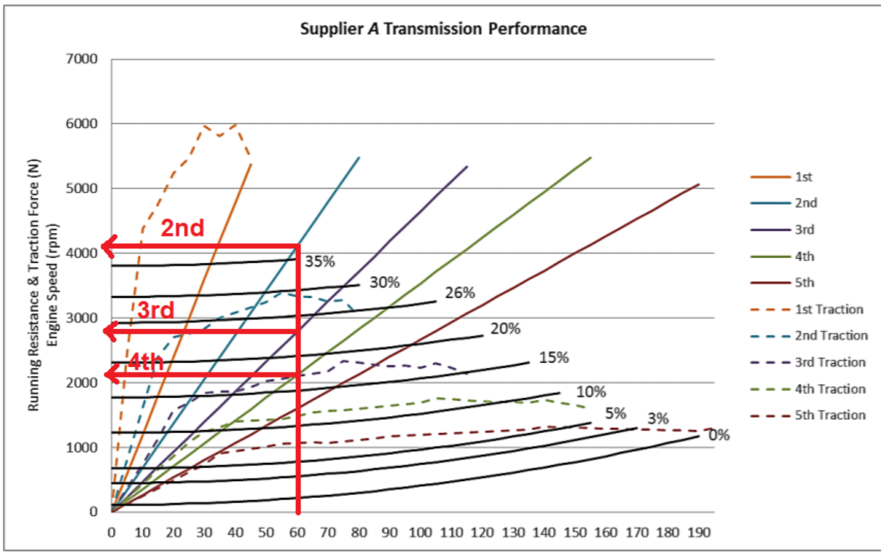


Figure 11: Supplier *A* transmission performance

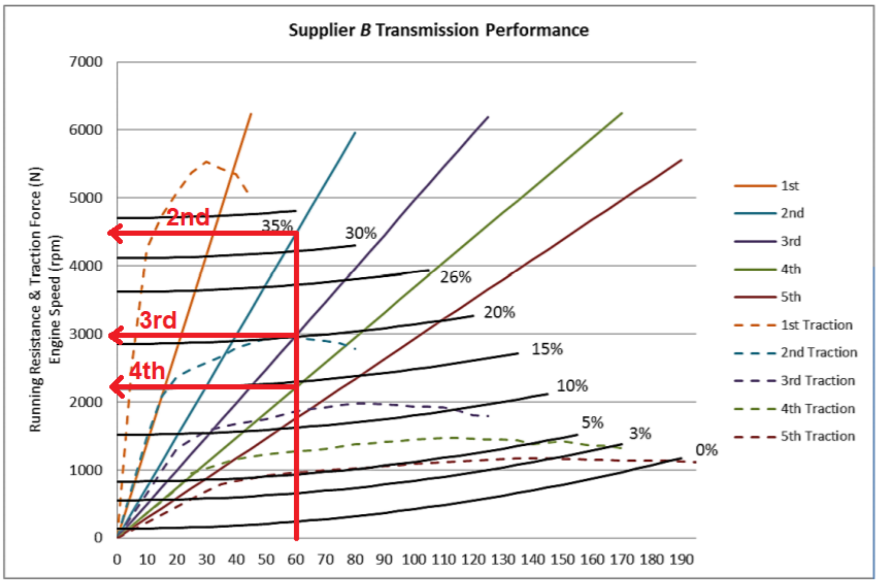


Figure 1 2: Supplier *B* transmission performance

To compare the fuel consumption, 60kph and 110kph were selected to observe. At the vehicle speed of 60kph, the transmissions are usually stay on 2nd, 3rd and 4th gear. According to figure 11, supplier A transmission has engine speed of 4100 rpm, 2700 rpm, and 2100 rpm at 2nd, 3rd and 4th gear respectively. According to figure 12, supplier B transmission has engine speed of 4400 rpm, 3000 rpm and 2200 rpm at 1st, 2nd and 3rd gear respectively.

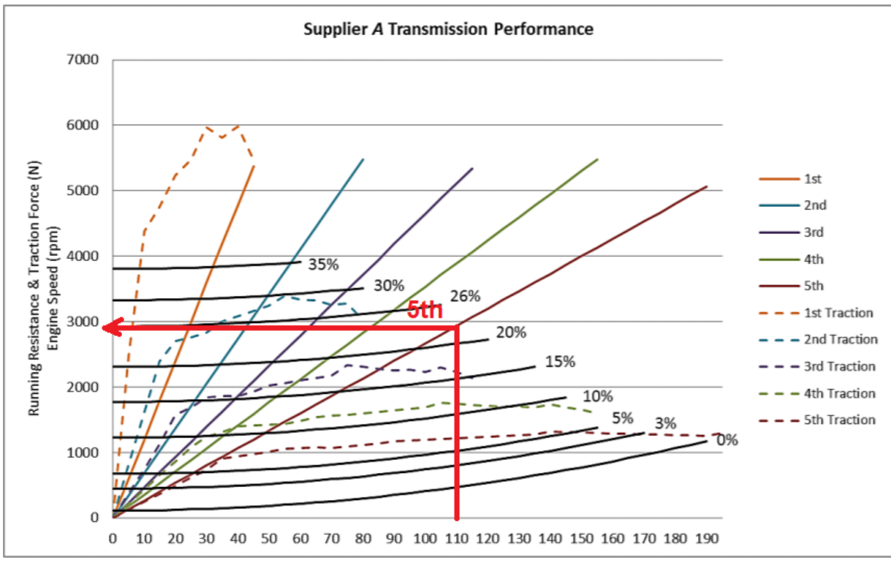


Figure13: Supplier *A* transmission performance

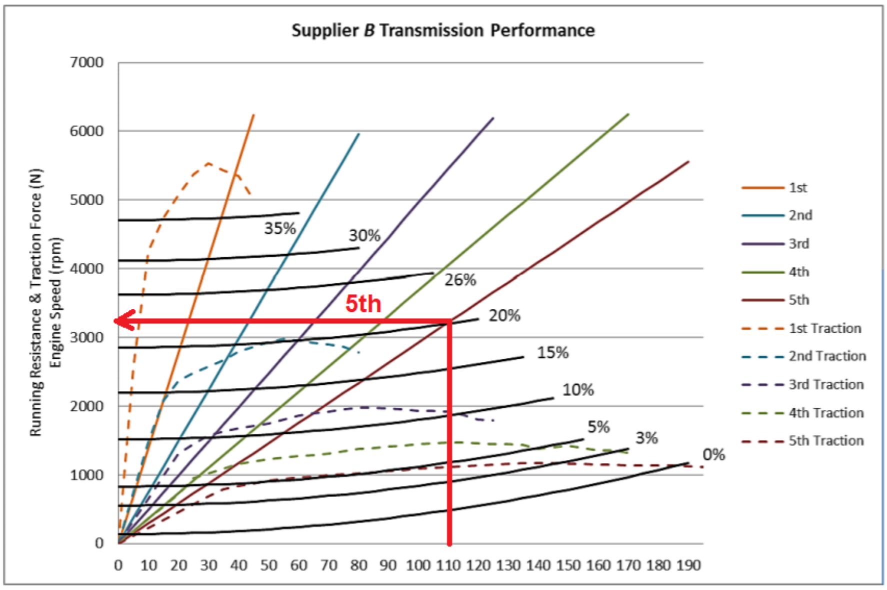


Figure 14 : Supplier *B* transmission performance

At the vehicle speed of 110kph, the transmissions are usually stay on 5th gear. According to figure 13, supplier A transmission has the engine speed of 2950 rpm. According to figure 14, supplier B transmission has the engine speed of 3200 rpm.

Based on the data, it shows that the supplier B transmission has higher engine speed at low/high vehicle speed. In general, the lower the fuel consumption the better it is. The higher the engine speed, the more the fuel consumed. Therefore, supplier B transmission would consume more fuel compared to supplier A transmission. Supplier A transmission has the lower fuel consumption.

Other than that, the emissions requirement for both suppliers A and B transmissions are EU3 and EU5 respectively. The emission standard of a vehicle shows the amount of toxic gas emitted to the environment. The higher the standard of emission of a vehicle, the lesser the pollution to the environment. EU5 indicates that the toxic gas emitted to environment or the pollution is lower than EU3, as EU5 is a later version of emission standard that introduced to the public. Therefore, the supplier B transmission has a better emission standard.

Table 1: After Sales

	Supplier *A* transmission	**Supplier *B* transmission**
Part price	RM3, 000	RM5, 500
Warranty	60, 000 km or 5 years	30, 000 km or 3 years
Transmission oil service	60, 000 km and 120, 000 km	
Transmission oil price	RM48/liter	RM30/liter
Testing cost	RM500, 000	
Emission requirement	Meet EU3	Meet EU5

According to table 1, Supplier A transmission is better in term of warranty as the coverage of warranty is 60,000km mileage or 5 years, which has higher mileage or longer in time compared to supplier B transmission. Besides, the part price of supplier A transmission is cheaper than supplier B transmission. Other than that, both transmissions require the service on transmission oil every mileage of 60,000km and 120,000km. The transmission oil price of supplier B is cheaper than supplier A.

Table 2:Overall Comparison

	Supplier A transmission	Supplier B transmission
Climb ability	✓	
Reponse at low/high vehicle speed	✓	
Fuel Consumption	✓	
Emission Standard		✓
Warranty	✓	
Part Price	✓	
Service price		✓

The ticks in table 2 indicates which transmission is better at the analysis. Fuel consumption and warranty is prior concern for vehicle, in table 2, it clearly shows that Supplier A transmission is better in terms of fuel consumption and warranty, therefore, supplier A transmission is recommended.

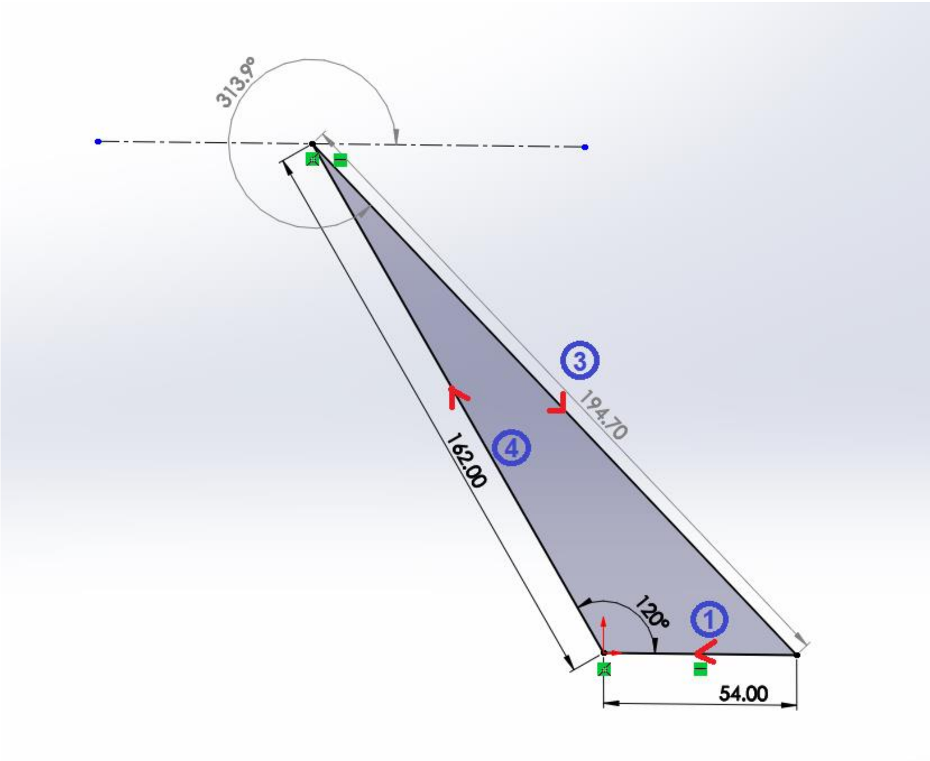
Task 2

Part a:

Table 3: Tabulation data

Plane	Mass (m) kg	Radius (r) m	Mass x Radius (m.r) kg.m	Distance from R.P. m	Mass x Radius x Distance from R.P. (m.r.l) kg. m^2
1	400	0.3	120	-0.45	-54
2	m_2	0.3	0.3 x m_2	0	0
3	m_3	0.3	0.3 x m_3	0.75	0.225 x m_3
4	400	0.3	120	1.35	162

Primary Couple Polygon:



To find m_3:

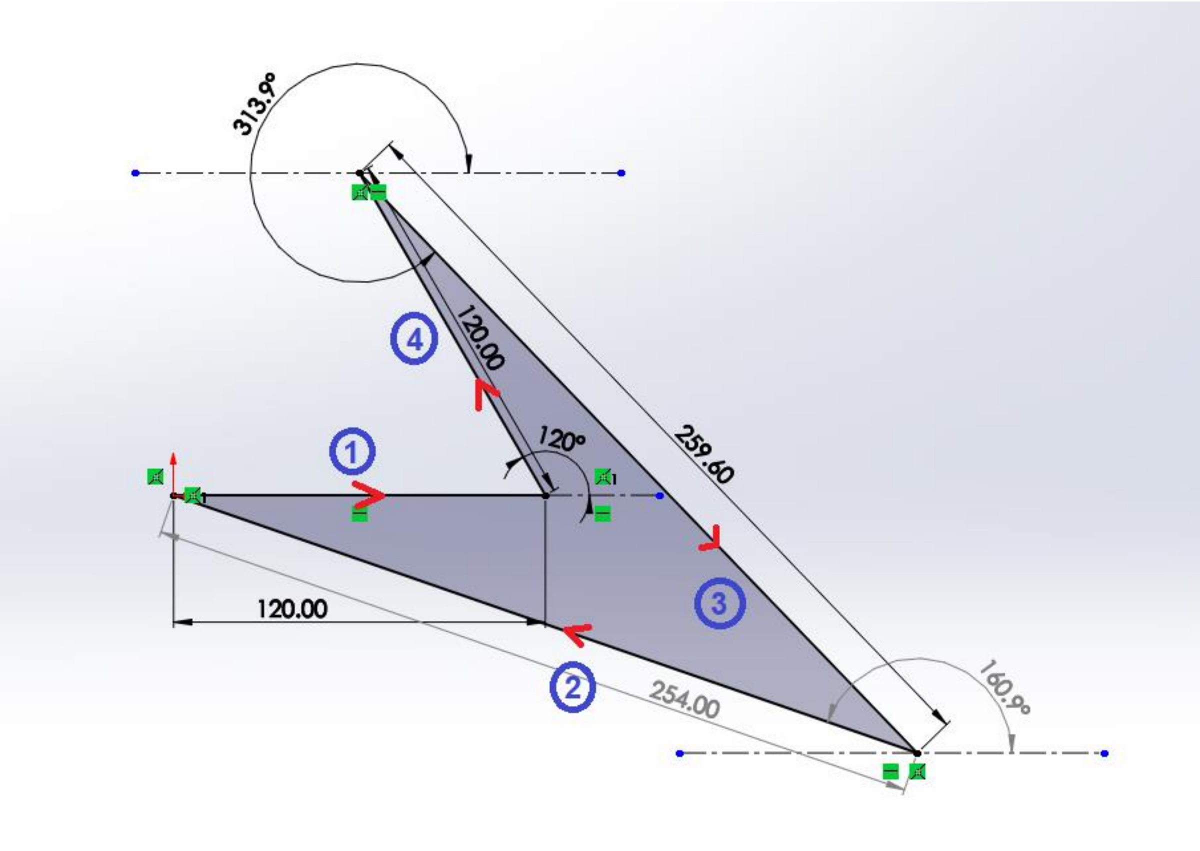
$0.225m_3 = 194.7$

$m_3 = 865.3333$ kg

To find θ_3:

$\theta_3 = 313.9°$

Primary Force Polygon:



To find m_2:

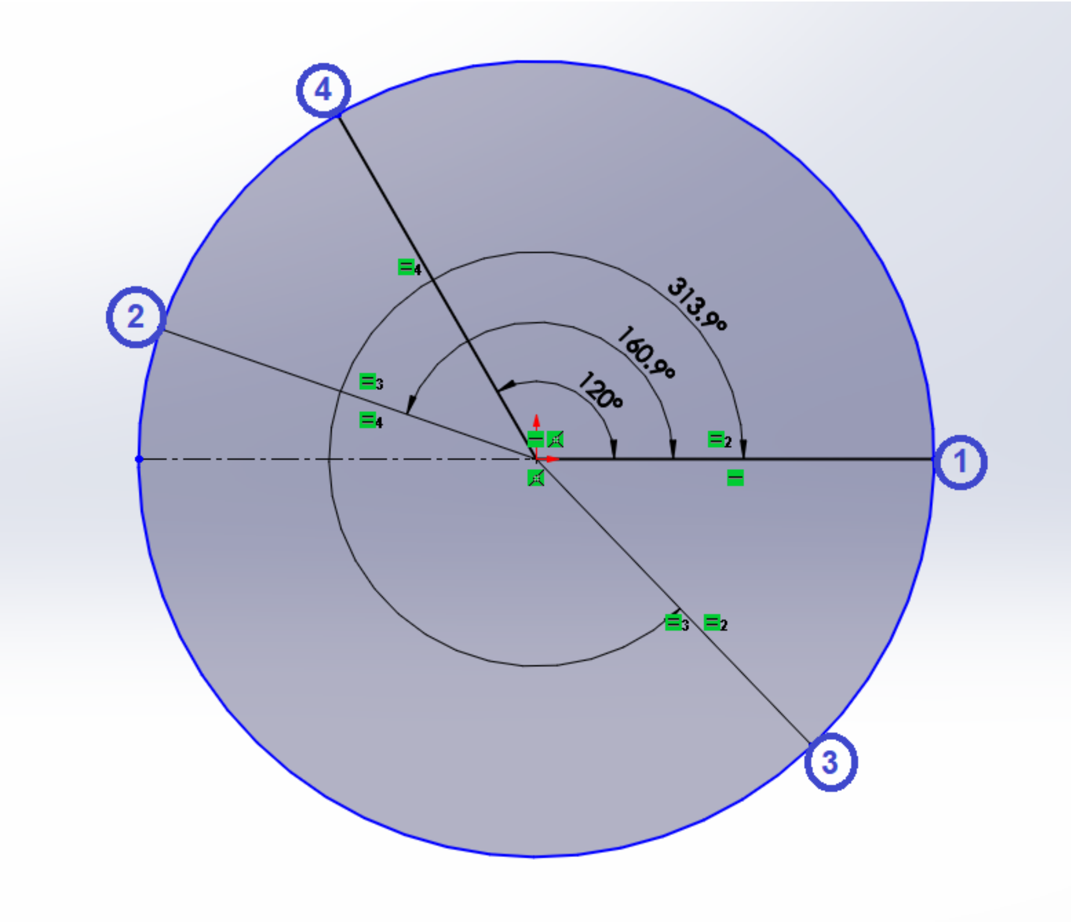
$0.3m_2 = 254$

$m_2 = 846.6667kg$

To find θ_2:

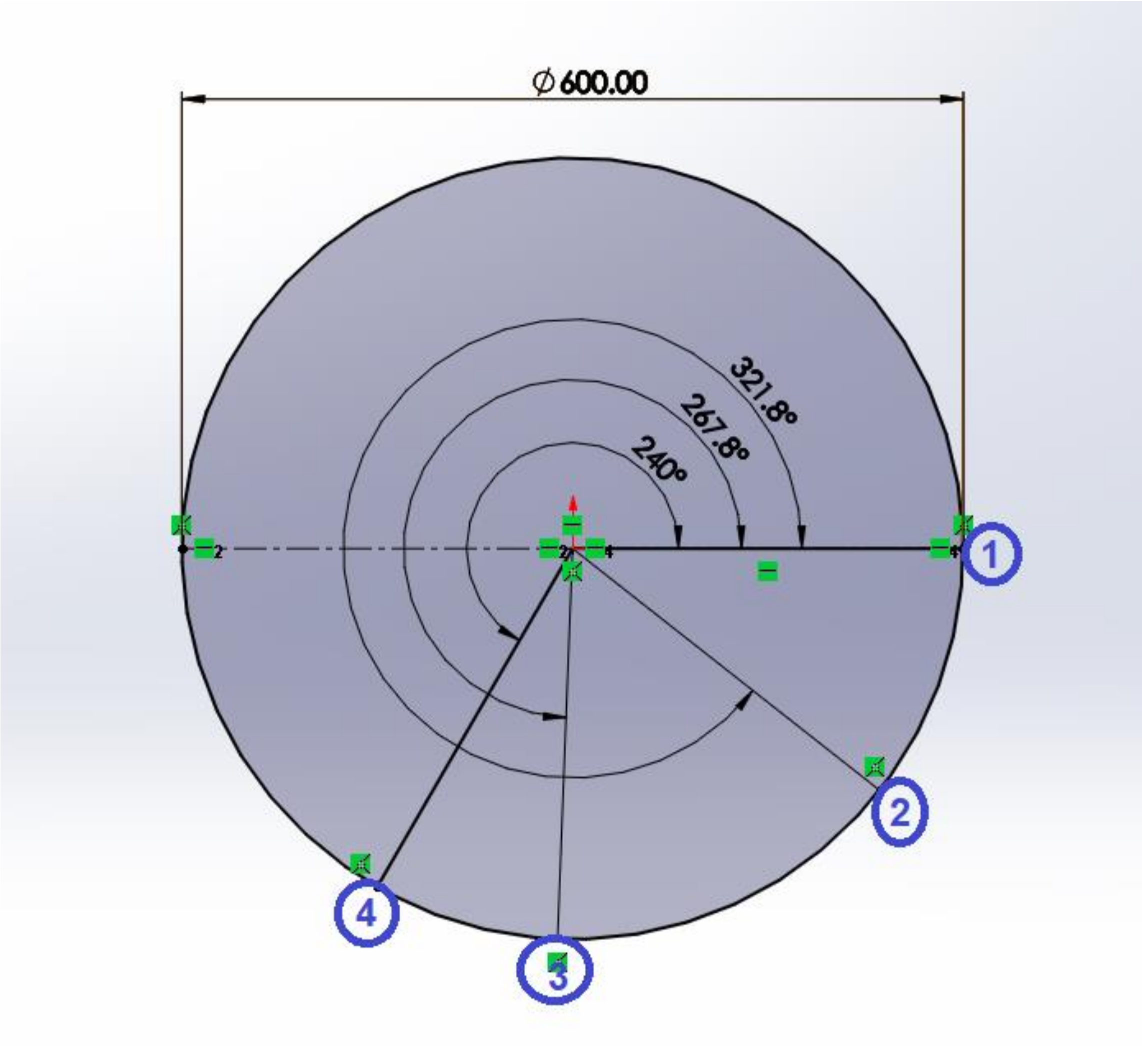
$\theta_2 = 160.9°$

Primary Crank Positions:

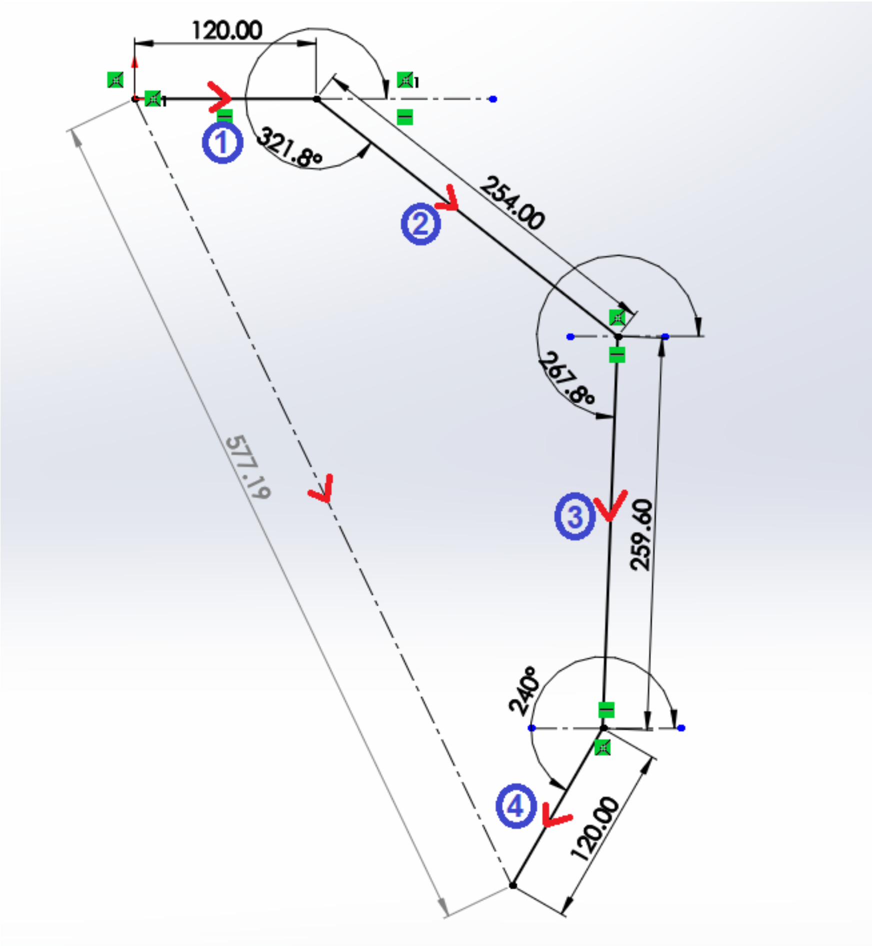


Secondary Crank Positions:

Rotate the primary crank positions twice of the angle to obtain the Secondary crank positions.



Secondary Force Polygon:



Part b:

The ratio of connecting rod length to crank radius is fixed, therefore n = 4

Table 4: Engine speed & Maximum Secondary Unbalanced Force

Engine speed (rpm)	rad/s	Maximum Secondary Unbalanced Force
0.0000	0.0000	0.0000
100.0000	10.4720	15823.9916
200.0000	20.9440	63295.9663
300.0000	31.4159	142415.9241
400.0000	41.8879	253183.8651
500.0000	52.3599	395599.7892
600.0000	62.8319	569663.6964
700.0000	73.3038	775375.5868
800.0000	83.7758	1012735.4603
900.0000	94.2478	1281743.3170
1000.0000	104.7198	1582399.1567

To determine the Maximum Secondary Unbalanced Force

Example of 100 rpm:

$$Maximum\ Secondary\ Unbalanced\ Force = 577.19 \times \frac{\left(100 \times \frac{2\pi}{60}\right)^2}{4}$$

$$Maximum\ Secondary\ Unbalanced\ Force = 15823.9916\ N$$

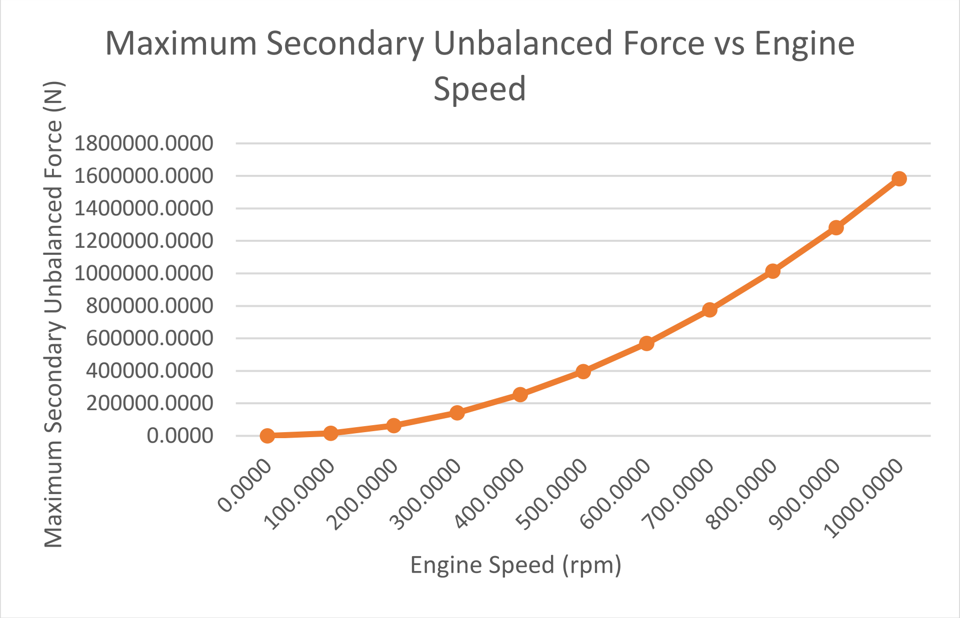


Figure 15

Part c:

The engine speed is fixed to be 300 rpm.

Table 5: Connecting rod length to crank radius ratio & Maximum Secondary Unbalanced Force

Connecting Rod Length To Crank Radius Ratio, n	Maximum Secondary Unbalanced Force
1	569663.6964
2	284831.8482
3	189887.8988
4	142415.9241
5	113932.7393
6	94943.9494
7	81380.52806
8	71207.96205
9	63295.96627
10	56966.36964

<u>To determine the Maximum Secondary Unbalanced Force</u>

Example when n = 5:

$$Maximum\ Secondary\ Unbalanced\ Force = 577.19\ \times \frac{\left(300 \times \frac{2\pi}{60}\right)^2}{5}$$

$$Maximum\ Secondary\ Unbalanced\ Force = 113932.7393\ N$$

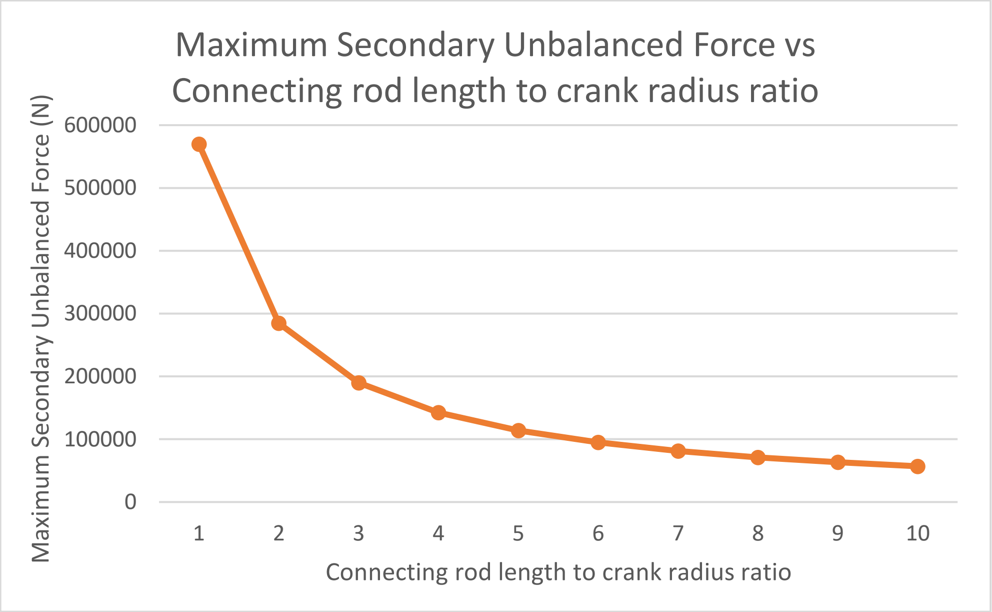


Figure 16

<u>Part d:</u>

<u>Conclusion</u>

According to figure 15, the graph shows an upward trend. When the ratio of connecting rod length to crank radius is fixed, the increase of engine speed results in an increase of Maximum Secondary Unbalanced Force. Therefore, when the transmission is at high engine speed, high maximum secondary unbalanced force was produced, and this led to the transmission to be shaky.

According to figure 16, the graph shows a downward trend. When the engine speed is fixed, the increase of connecting rod length to crank radius ratio results in a decrease of Maximum Secondary Unbalanced Force. In locomotive, the distance between the crank and connecting rod are kept far apart to reduce the effect of secondary forces. Therefore, by having a long distance between the crank and connecting rod will increase the chances of minimizing the effect of secondary forces.