<abstract><heading>Summary</heading>In this assignment, researches have been done on the types of engines that are usually used for racing. The four types of racing engines that was of interest were the Formula, Rally, Sports and Motorcycle racing engines. The specifications of these engines have been summarized in Appendix A and B so that one can compare their important parameters. Appendix A shows all the racing engines, of which their individual performance will be discuss in the content of this report. Appendix B is a table which accumulates all the information obtained about the four racing engine requirement and their overall comparisons are also included in the main text. In this report, we also accessed past and future developments of each of these racing engines. <picture/></abstract><heading>Introduction</heading>In 1894, the idea of car racing was raised once a series of petrol-fuelled cars were constructed. The first official race was held in Chicago, Illinois on 2nd November in 1895 and racing engines were improved exponentially during the 20 th century. Researches on different engines which usually used in racing were performed and discussed in this report. Engine used for general automotives was internal combustion (I.C.) engine in which the mechanical power of vehicle was produced by combustion of fuel within the combustion chamber. Internal combustion engine could have either two-strokes or four-strokes and either spark ignites or compression ignites. Gasoline, diesel and natural gas could be selected as the fuel in a SI engine. On the other hand, two major types of IC engines were identified: Rotary engine and Reciprocating engine. The major representative of rotary engines in automotive industry was the Wankel engine (Fig 2) which was the most highly developed rotary engine since 1970s; such engine was used due to the compactness and high power performance. <picture/>However, the development of Wankel engine was suspended in most of the companies due to the arising environmental regulations as well as the effect of the oil crisis. The most recent car operated by Wankel engine was the Mazda RX-7 which produced in 1999. In automotive racing industry, only particular specifications were selected and employed since the efficiency could only be improved by such specifications. Different cylinder configurations such as single, in-line, v-type, w-type, u-type, opposed cylinder, opposed piston and radial could be found in IC engines. However, in-line and v-type were the most commonly used configurations in automotive racing engines. Further more, the common numbers of valves employed in each cylinder were 2 (1 intake, 1 exhaust), 4 (2 intake, 2 exhaust) and 5 (3 intake, 2 exhaust). Generally 4 valves were employed in racing engine. . Compare to normal engines, limits such as peak operating cylinder pressure were pushed up in some racing engines so that a higher performance could be obtained. Besides, the horsepower and fuel economy could be increased by maximizing the cylinder pressure. Although the cylinder pressure could be increased by increasing the compression ratio, alternative technique could also be used since cylinder pressures could be altered significantly by using camshaft selection, carburetion, nitrous and supercharging. Compression pressures could be adjusted drastically by installing supercharging, turbo-charging or intercooling system. However, apart from installing extra equipment to improve the effectiveness and efficiency of racing engines, the durability and lifetime were also a significant factor to consider since racing cars might require to operation for a long time without any failures <heading>Type of Racings</heading>In the report, a series of engines used in different automotive racings including formula racing, rally racing, sports racing (including endurance) and motorcycle racing were presented. In fact, the features required in racing engine were totally depended on types of racing and performances of different racing engine were adjusted in order to meet the specific purpose and provide a best fit performance. However, high acceleration, high maximum speed, high power, high torque, light weight and high efficiency of engine cycles were generally the ideal for racing engines. For instance, high power output was necessary for rally engine since such racing might consist of climbing uphill or operating under poor conditions. To conclude, particular engine performance could be adjusted in accordance with racing course conditions and requirements. <heading>Formula Racing</heading>Formula racing was a type of single-seater racing which involved a variety of special designed high performance cars. The wheels of formula cars were not covered and aerofoil wings could always be found at the front and rear of the car (Figure 3). Formula engines should have an extremely high maximum speed, extremely high acceleration, high torque, long life span, high operational temperature and extremely light weight in order to perform effectively on a special designed racing course. <picture/><heading>Rally Racing</heading>The first World Rally Championship (WRC) was held in 1973 and highly modified cars were competed on normal roads as well as under poor conditions which included dirt, swamps (water resistance) and snowy surfaces (Figure 4). Rally engine should have an extremely high torque, extremely high horsepower, high acceleration, long life span and high operational temperature in order to maintain the car under safety condition as well as effectively operated. <picture/><heading>Sports Racing</heading>Sports racing cars were modified cars and were normally operated on racing courses (Figure 5). Endurance racing is part of the sports racing where races were usually carried out over a long distance and vehicles were usually driven by a team of two to three drivers. As similar to formula engines, sports engines should have a reasonable maximum speed and torque during operation, extremely long operational time, a long life span and high operational temperature were also essential to be considered before the production process of racing engine. <picture/><heading>Motorcycle Racing</heading>Finally, motorcycle racing is a contest involving motorcycles competing with each other (Figure 6). Design of motorcycle engines varied largely in order to meet the requirements for different type of races. Normally motorcycle engine required to have light weight, long life span, high operational temperature, extremely high acceleration and maximum speed. <picture/><heading>Technical features</heading>Additional features could be employed in different racing engines so that the performance could be improved further. Forced induction systems such as turbocharger and supercharger were explained as well as cooling systems and carburetor. 1. Turbocharger - An apparatus to boost the horsepower of engine without significantly increased its weight, operated by pressurizing the air flowing into the engine's cylinders in order to get more fuel to be burnt during each stroke. Advantage of compressing the air was more air could be squeezed into a cylinder, hence more fuel could be added and more power could be obtained from each explosion in each cylinder. More overall power could be produced than the same engine without the charging (Figure 7). <picture/>Supercharger (Figure 8a) - The mechanism was nearly identical to the turbocharger, the major difference was the power supplies in order to run the air compressor. In supercharger, a belt was connected directly to the engine and power was transmitted via the belt. For turbocharger, power was obtained from exhaust stream since the exhaust run through a turbine which in turn the compressor was span. A graph was shown the variation of power with rpm with and without supercharger (Figure 8b). <picture/><figure/>3. Cooling systems - Either liquid-cooled or air-cooled technique was generally employed in racing engines. i) Liquid-cooling: Fluid flowed through pipes and ducts within the engine, heat was absorbed by the fluid and engine was cooled as the liquid passed through. The fluid was then passed through a heat exchanger or radiator and heat was transferred from the fluid to the air blowing through the exchanger. ii) Air-cooling: An old-fashioned cooling technique, engine block was covered in aluminum fins rather than circulating fluid through the engine so that heat could be conducted away from the cylinder. A powerful fan was used to force air over these fins and the engine was cooled by transferring the heat to air. 4. Carburetor - The right amount of gasoline with air could be mixed so that the engine could run properly. <heading>Designs of racing engines</heading>In an internal combustion engine with multiple (more than one) cylinders, the cylinders and piston could have V-, in-line, horizontal, w type, opposed piston and radial configuration. The most common configurations used in racing engines are the V- and in-line configurations. <heading>1. V-configuration:</heading><picture/>V-configuration engines would have their cylinders and piston arranged in such a way that they form V shapes as shown in Figure 9 above. Engines using this configuration are named V2, V4, V6, V8, V10, V12, V16, V18, V20 and V24. The V configurations have been widely applied in racing engines as it helps to minimise the engine length and weight as compared to the in-line configuration. The cylinders can be arranged with different V-angles. The bigger the V-angle of an engine, the more stable it is as it has lower centre of gravity. However, large v-angle also gives rise to vibration problems. Therefore, despite increasing the V-angles would lowered the centre of gravity, it also increased the vibration. On the other hand, small V-angle engines will be less stable as the centres of gravities would be higher. Examples of engines with large V-angles are V2, V4, V6 and V10. <heading>2. In-line configuration:</heading><picture/>In-line configuration is another configuration that is commonly used in racing engines. The cylinders in an in-line engine were arranged in one straight row parallel to each other. This can be applied for all multiple cylinders engine but is more commonly found in four- and six-cylinders engines. Its simple structure makes it easier in production than V-configuration engines. Due to its simple shapes it would be relatively easy for it to be fitted into the car chassis with different positions and can run rather smoothly. The disadvantage of in-line engines is that they are longer than V engines. It will be hard to install in-line engines into small cars and the cooling of engine by air can get difficult if it had been installed in inconvenient position Examples of in-line engines are straight-twin, straight-3, -4, -5, -6, -8, -10, -12 and -14. Straight-4 is the most commonly used in-line engine at the present. <heading>Sports Engine</heading>Sports racings consisted of a variety of competitions between modified cars and were normally taken place on a specific racing course. Due to the enormous area sports racings have covered, only endurance racing was mentioned in this report. <heading>1) Ford GT 2005 (Ford's MOD)</heading><picture/><table/>The first Ford GT was built in 1963 and was became the world's best endurance racing car in mid-1960s. Ford GT achieved a result with flying colors as such vehicles placed 1-2-3 at the 24 Hours of Le Mans in 1966 as well as won the next three consecutive years. The Ford GT was reconstructed in recent years in order to celebrate the centennial of Ford Motor Company. A mid-mounted, all-aluminium 5.4L DOHC supercharged V-8 engine that produces 550 horsepower was used in this generation. Compression ratio was 8.4:1(in/mm) and Sequential multi-port Electronic Fuel Injection (SEFI) was employed in the engine with dual injectors per cylinder. The MOD V-8 featured aluminium four-valve heads, forged crankshaft, H-beam forged rods and aluminium pistons fed by an Eaton screw-type supercharger, all combined and produced more than 500 hp horsepower and 500 ft-lb of torque. In 1966 a new prototype design (GT40 MK2) was introduced with a 427 c.i. (7000cc) engine, produced a 485 BHP power at 6,200 RPM and 475 Ib-ft of torque at 4,000 RPM. In the same time as GT40 MK1 was being developed, a road used version (GT40 MK3) was designed and a 289 ci. (4700cc) engine was used which could produced 306 BHP power. Between 1966 and 1967, a new GT40 was introduced (the J-Car). However, the final product was not very satisfied as such vehicles were mainly designed from Ford's styling department. During 1968/69 seasons, the GT40 Mk1 was redeveloped and a stronger engine was employed. 400 bhp of power at 6,500 rpm and 385 lb-ft of torque was finally achieved in 1968. In 1969 the power was raised further to 425 bhp at slightly lower revolution of 6,250 rpm and 396 lb-ft of torque at 4,750 rpm, using a 302 ci. engine and other improvements. The Ford GT40 was the origin of Ford GT and was firstly produced in 1964; the engine of first prototype car (GT40 MK1) used a 4200cc Ford V8 engine, with aluminium block and heads. The engine was dry sumped with IDA Webber carburetor atop. The performance was 350 BHP of power at 7,000 rpm and 275 lb-ft of torque at 5,600 rpm. In current design, aluminium was used in most of the parts of engine in current Ford GT due to the high strength and excellent heat transfer, so that the main objectives of endurance racing (long life span, long operational time and safe operation) could be fulfilled. However, some components were manufactured by forgings instead of castings; potential hazard might exist by using such an unseasoned manufacturing process as casting was the conventional manufacturing method of automotive components. <heading>Sports Engine - Overall Development</heading>The performance was improved by adding new components such as supercharger. The 32-valve, 330 cubic-inch, 90-degree all-aluminum V8 engine was placed behind the driver in order to lower the centre of gravity of the vehicle. Performances of 373kW of power @ 6000rpm and 678Nm of torque @ 4500rpm were generated by the engine. Forged components (such as crankshaft, connecting rods and aluminum pistons) were also utilized in order to deal with extra pressure of forced induction. Aluminium components were become familiar due to the light weight and extremely high levels of torsional rigidity. Forgings technique would also become common after the correspondence processes were further improved. <heading>Rally Engine</heading>Rally engines were required to operate effectively even under poor conditions such as in swamps (water resistance), dirt and on snowy surfaces. The engine also needed to generate sufficient power in order to drive the rally car uphill. Two rally engines were shown below: <heading>1) Subaru Impreza WRC 2004 (EJ20)</heading><picture/><table/>The first Impreza was found in October 1992 and horizontally opposed, four-cylinder, all-alloy EJ20 engine for a displacement of 1.994 L with quad camshafts, 8.0:1 static compression, a single turbocharger and intercooler was employed in this model. The boxer engine was in accordance with a specially reinforced "semi-closed deck" engine block, forged aluminium alloy pistons and forged high-carbon steel which linked to rods and exhaust valves (sodium-filled). The theory behind using a 'flat four' was the engine sat lower in the car in which the car's inertia could be benefited and hence a lower centre of gravity could be obtained. In 2003, the output of this turbo charged engine was increased to 165 kW (225 PS), dampers with multiple phase valves were also used in order to obtain high performance and steering stability. Besides, the cooling performance was also enhanced by using a different shape of the inter-cooler water spray nozzle and the shape of the air baffle plate within the air scoop. Nevertheless, developments were still carried out during 2004 in order to remain effective and competitive in the WRC. A wide range of performance upgrades were conducted including using a direct water injection system and increasing the size of IHI turbocharger housing so that stable engine combustion could be obtained. Aluminium block and heads were employed in order to be operated in high temperature effectively. Area of air intake was increased and hence the cooling system including V-mount radiator could be improved. On the other hand, AVCS (Active Valve Control System) was also introduced and the inlet camshaft timing over a 35-degree range was varied in order to improve emissions, tractability and low rpm torque. The EJ20 boxer engine was also modified with a twin scroll turbo, drivability was greatly enhanced by the increased torque at low speeds, while the improved acceleration was particularly significant in rally race. <heading>2) Mitsubishi Lancer Evolution WRC 2004 (4G63)</heading><picture/><table/>Lancer Evolution was firstly appeared in 1973 and was equipped with the 4G63 engine. The 4G63 engine consisted of an 85.0mm (3.35") bore and 88.0mm (3.46") stroke, for a displacement of 1997 cc. Twin contra-rotating balance shafts were housed inside the block and Multi injection technique was employed. The engine was mainly consisted of cast iron block and an aluminium alloy cylinder head. A new turbocharger fitted with the WRC regulation 34-millimetre intake restrictor, new intake and exhaust manifolds, and new internals were used in the engine in order to obtain a higher efficiency. In 2003, refinements were performed on intake and exhaust systems, aluminium induction piping, and weight reduction measures by using a cast-magnesium cylinder head cover and hollow camshafts. The intake, exhaust, turbocharger impeller and housing, camshafts and crankshaft were all developed in 2004, in accordance with the technology already achieved in different Lancer Evolution over the past 10 years. Camshafts were design to hollow so that the rotating inertia was reduced. Moreover, the "twin-scroll" impeller in turbocharger was modified by doubling the amount of fins. Dual chambers were used in exhaust housing, the exhaust gases were routed from cylinder 1 and cylinder 4 to one side of the twin-scroll turbocharger and gases from cylinder 2 and cylinder 3 to the other side of turbocharger. Efficiency would be increased by improving the airflow intake. However, the WRC regulation was conflicted by this development since only a maximum of 34-millimetre intake restrictor could be used. Although downforce was a vital factor of competitive car on rally racing, good cooling was a key prerequisite on a turbocharged rally car since the ambient temperature on rally car could usually exceed 30 degrees Celsius and the temperature was often the highest on racings which carried out at the lowest average speeds. In order to achieve a high efficiency and effectiveness in rally engines, airflow beneath the rally car could be used and considered. In 2005, improvements to the rally engines would be carried out by employing a new waste gate, anti-lag valves as well as an improved engine control. On the other hand, the turbo-charger would also be investigated in order to determine the change in efficiency. The performance and tuning possibilities of such engines would also be significantly developed and become more accurate by carrying out different improvements. <heading>Rally Engine - Overall Development</heading>Over the past few years, the development of rally engines was improved from only concentrated on the modification and replacement of engine components (such as dampers, turbocharger housing, intake and exhaust systems, piping, head cover, hollow camshafts, twin scroll turbo...etc) to introducing new components and technique (such as airflow beneath the rally car, new waste gate) in order to improve further and achieve a better performance. On the other hand, exact values of some performance such as accelerations and maximum speeds were not defined since those figures could be adjusted easily by tuning. <heading>Formula Racing Engine</heading>Formula racings involve a variety of high speed and high performance cars competing against each other. At present, the most famous Formula race is Formula-1 (F1) racing. In this assignment, most research was done on Formula-1 engines. Formula-1 car engines have excellent performance as they are about ten times more powerful than normal car engines. To ensure all races are reasonably fair, FIA (Fédération Internationale de l'Automobile) have put forward some limitations to the engines of the cars that were competing in the races. For instance, the engine must be four strokes and consist of 10 circular cylinders with less than 5 valves on each cylinder. Supercharging is not allowed in Formula-1 cars. At present, the 10 cylinders of the engines are usually arranged in V configuration. They often have capacities of about 3000 cc capacity and can generate more than 800 bhp. High torque of the engines means high power output (i.e. high horsepower) as the number of engine cycles per unit time is depend on the torque. Special materials (such as Aluminium alloys, ceramic etc.) were used to manufacture the engine's components for Formula-1 for weight reduction purpose and also to reduce the chances of overheating of the engines. The cooling of the engines was very important in Formula racing cars especially in Endurance racing since the car was required to run for a long period of time (typically 6 hours, 12 hours and 24 hours) over the runway course in order to test the engine's durability. Formula-1 car engines are all air cooled. Less dense ceramic was used in making the internal components of the engines so that it was easier to accelerate and also reduce the engine's fuel consumption. The overall size of the engines should be reasonable light and small, so that they could be easily fitted into the chassis. The numerical data for the engines' torques and compression ratios (CR) are not available in all of the sources. This may because these data have to remain confidential. Following are some examples Formula-1 racing engines: <heading>Ferrari :</heading><picture/><table/>Figures 5a and 5b above are Ferrari F2003-GA single-seater racing car and Type 052 engine respectively. Ferrari F2003-GA was Ferrari's 49 th single-seater racing car entering the FIA Formula-1 world championship. Similar to the previous generations of engines, the 3000 Ferrari (type 052) engine is load-bearing and is fitted longitudinally into the chassis. It has a V configuration and 10 cylinders arrangement with 4 valves per cylinder, i.e. 40 valves. It is a Spark Ignition (SI) engine with Magneti Marelli static electronic ignition. Fuel will be fed into the engine by Magneti Marelli digital electronic injection. Type 052 is an evolution of the former 051 engine with several improvements that increase the engine's performance and usability. Size and weight of the engine were reduced as new materials have been used for manufacturing it. The centre of gravity of the car is lowered and therefore improving the overall weight distribution. Maximum engine revolutions of type 052 engine would be about 200 rpm higher than that of the type 051. Further development of the engine would be carried on in order to improve the horsepower and its performance. The types of engines that Ferrari would develop in the future will tend to be more reliable and can integrate well with the car. <heading>Renault:</heading><picture/><table/>Renault R24 as shown in Figure 6a was a single-seater built by Renault to compete in the Formula-1 racing in year 2004. The engine used to drive R24 was the Renault RS24 engine, which was an improved evolution of the RS23 engines that had been used in the Renault R23 (2003). Renault had been developing R24 since September in order to improve the overall engine performance. The RS23 engine launched in 2003 was a 111-degree V10 engine. It was generally reliable except that it has major problems with vibrations. Therefore RS24 had been developed from RS23 by changing some configurations and its design is based on the Supertec engines. RS24 has a 72-degree V configuration with 10 cylinders arrangements. As RS24 engine is higher, it has a centre of gravity that is 20mm higher than that of RS23. But according to the Renault F1 team, this problem has been compensated by making changes to the engine's casing. Therefore, the centre of gravity of the car R24 is not much higher than that of R23. The problems of vibrations have been improved in the development of the RS24 engine. In February 2005, Renault launched a new RS25 engine that has been developed from RS24. RS25 is basically the same as RS24, but its centre of gravity has been made lower. After the 72-degree V10 engines (RS24 and RS25), Renault was planning to develop a new 90-degree engine. The future developments for Renault engines will be more on weight reduction as well as improving its reliability. <heading>Formula Racing Engines - Overall Development:</heading>In 1950s, carburetor was widely used to feed fuel into the car engines. Shortly after, more effective direct fuel injection system was introduced by Mercedes. Renault then introduced turbocharged engines into F1. But the cooling systems of engines was not well developed, many turbocharged cars went down due to overheating. During the 80s, the developments of F1 engines were mainly on increasing their torques and the horsepower. But these increase in horsepower reduced the handling of the cars. The ground-effect of the cars were improved which increase their cornering speeds. This made it even harder to control the cars. During that period of time, many deaths of F1 driver were caused by severe accidents during races. In 1989, turbocharged engines were banned by F1 and were replaced by 3500 cc induction engines. In early 1990s, different companies were concentrating on the development of the 3500cc induction engines. The first 700 hp 3500cc induction engine was built which was much better than the previous racing engines. A 'baffle' had been introduced to enhance the cooling of the engines. F1 limited the capacity of the engines to 3000 cc in mid-90s. With the capacities limited, the engines could only be developed further by improving the mass centralization and increasing the horsepower. Horsepower can be increase by increasing the piston's bore and decreasing the size of cylinders as these will improve the volumetric efficiency of the engine. Finding the optimum cylinders configurations can improve the mass centralization (stability) of the car as well as the overall performance. <heading>Motorcycle Racing Engine:</heading>Motorcycle racing is a variety of sports involving motorcycles competing with each other. Some common examples of motorcycle racings are Isle of Man TT (road racing), MotoGP (circuit racing), Daytona (endurance racing) etc. Engines of motorcycles are gasoline engines and can be either two strokes or four strokes. They either use fuel injection or carburetors to feed the fuel-air mixture into the combustion chamber. Motorcycles used for racing are mostly four-stroke engines with multiple cylinders. The power of an engine depends on the number and sizes of its cylinders. Therefore, increasing the sizes and number of cylinders in an engine would increase its power, i.e. increase the engine's displacement. Motorcycles engines at present can have single-cylinder, two-cylinder, four-cylinder or six-cylinder and their displacements ranges from 250 cc to over 1500 cc. Most motorcycles nowadays often have two or four-cylinder engines. Engines with high displacement have higher fuel consumption and therefore generate more power. A multiple cylinder engine can have its cylinders arranged in horizontal, inline or V configurations. As mentioned beforehand, the main problems with V configuration engines were its vibrations and high centre of mass. Among the three configurations, the horizontal configuration has the best weight distribution (lower centre of gravity) and also produced the least vibrations. The following is an example of a racing motorcycle: <heading>Honda CBR1000RR:</heading><picture/><picture/><table/>Figure 8a shows a picture of the Honda CBR1000RR motorcycle and Figures 8b and 8c show the 998cc liquid-cooled engine that drives the motorcycle. The CBR1000RR engine has a displacement of 998cc and with in-line cylinders configuration. The piston's bore and stroke sizes were made different from that of its predecessors so as to improve its compression ratio, i.e. higher volumetric efficiency. Its fuel tank is placed at the centre and fuel was fed into the engine through a dual stage fuel injection (DSFI) carburetor. Honda CBR1000RR was developed based on the previous RC211V with improved horsepower. Therefore, CBR1000RR is as reliable as RC211V but with higher maximum speed. CBR1000RR bike inherited most of RC211V's body structures such as the Aluminium frame, the suspensions etc. As the swing arm of CBR1000RR bike had been made longer, the size and structure of the engine had to be modified in order for it to fit into the bike chassis. The front to back dimensions of the engine was being shortened by arranging its main shaft, countershaft and the crankshaft in a triangular pattern with countershaft below the main shaft. The engine had been placed towards the front of the bike body to improve the overall weight distribution of the bike, i.e. more stable. In the past, Honda development group has been working on the weight centralization aspects, i.e. to improve the stability of the bike. Based on the researches that had been done, the future evolutions of the Honda racer engines would be more on increasing the engine's horsepower and torque. <heading>Motorcycle Racing Engine - Overall Development:</heading>The first ever engine used to power a motorcycle was a steam engine which was built in 1867 in the US. It was a two-cylinder engine that powered the bike by burning charcoal. In the 1880s, the first gasoline engine for motorcycle was then built which was a single-cylinder gasoline engine (reciprocating). At this early stage, the fuel feeding system of this simple engine was a spray-type carburetor. Later in 1894, a water-cooled parallel two-cylinder engine was developed. The cylinders were moving to and fro simultaneously to create motion to the rear axle by transmitting through connecting rods. An elastic band was placed on each side of the cylinders for energy storing purpose and to enhance compressions in the cylinders. A year later, a smaller four strokes engine with capacity of about 138 cc was built. It generates a power of 0.5 hp which was very small compare with the engines output power nowadays. Shortly afterwards, the AV-Twin with speed gearboxes was built. The first motorcycle endurance race was held in 1907 on the Isle of Man. In 1916, a two-cylinder engine with four valves per cylinder was developed and was used in various races as its maximum speed was over 120 mph. the development for the motorcycle racing engines had come to a halt during the two World Wars. But not long after World War 2, 125 cc bikes were built based on the previous models. From then, the development of the motorcycle engines was more on increasing the horsepower and the stability of the bike. Horsepower can be improved by changing the dimensions and configurations of the cylinders and pistons. While the stability is depend on the weight distributions of the bike. <heading>Performance Analysis and Discussion</heading>The performances for each racing engine were plotted in Appendix A and the comparisons of performance for different types of racing engines were plotted in Appendix B. Firstly, all the displacements of formula and rally racing were very closed to 3000cc and 2000cc respectively, however the maximum possible values for those racing vehicle should be larger since those performances were achieved under some racing regulations. On the other hand, the torque and compression ratio of formula racing engines as well as the compression ratio of rally racing engines were missing on the table due to those performance might be confidential to public. In formula racing V10 engine were normally used since the racing engine could only consist 10 cylinders in accordance with formula racing regulation. Most of the rally engines were employing inline configuration except for Subaru Impreza since a more efficient flat configuration was used. Further more, the combined table in Appendix represented the requirement of different racing engines. Ten cylinders were used in formula racing engine since the vehicle required an extremely high speed. Besides, the displacement of sports racing engine was enormous compared to the others, due to the corresponding vehicle (Ford GT) was an endurance racing vehicle, hence an extremely high value of displacement was reasonable. Conversely, the total weight of motorcycle was pretty light, therefore the fuel consumption and displacement required were not necessary to be high. The power of formula engine was the highest as the formula car needed to achieve a highest possible acceleration. On the other hand, the motorcycle power was the lowest as the weight of the vehicle was small; hence only low force and power were needed in order to drive the vehicle. Although the torque of formula engine was not available, the expected torque of formula engine should be greater than the Ford GT (500lb-ft). <heading>Conclusion</heading>Firstly, Wankel engines obtained a high power performance and were familiar in automotive industry during 1990s. However, the development was suspended due to the arising environmental regulations and the effect of the oil crisis although the future development of this type of engine was enormous. In conclusion, the performances of different racing engines were totally depended on the type of race. For instance endurance vehicle would require a high displacement whereas a motorcycle would not since endurance race needed a larger capacity of fuel. Besides, the performance could be improved by inserting extra components such as turbocharger and cooler, by modifying/replacing the current components or by either employing specific valve configuration in order to lower the centre of gravity of the vehicle. Light weight and high strength material such as aluminium alloy could also be used so that a lighter but stiffer product could be achieved. The future development of these racing engines would be tends to increase the horsepower by developing new systems to assist the current operations. Improvements of racing engine could also be achieved by developing individual components such as piston, crankshaft, camshaft, head cover...etc.