Drivetrain Task:

01. Compare the different types of differentials:

Open differentials:

-Is the most regular type of differential and it used for good road Conditions

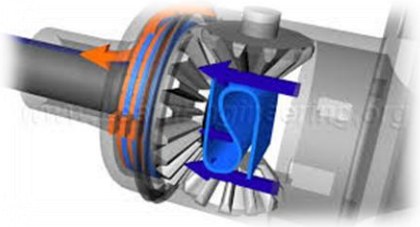
-Used for family sedans and economy cats.

-Less energy lost

-Limit the amount of Power Produced by the Vehicle

Limited Slip differentials

-It's an improvement of open differentials by using clutch or fluid



-Used for racing cars, off roads Vehicles and Performance cars.

-1. different wheel speed on one axle 2 reducing tire wears 3. allows the wheels to send torque with more traction 4. offers a very smooth operation (more than locked) -1. It Can't lock Completely 2. the effect will be reduced

Locking differentials

-It's a type of differential that used in situations needs both Wheel have the same RPM.

-It's used for off-roads cars

-1. provide torque for the wheel with more traction 2. Simple and very effective.

-It's not allowing difference in wheels speed

Torque vectoring

- It's Called active differential that uses a set of sensors and electronics to receive data from Various matters

  like road surface and throttle Position

- It is used for rear-wheel-drive vehicles and all-wheel drive

- It allows the outer wheel to give more torque as it gets closer to the turn

- Cost and Complexity.

Torsen differential

-It means torque sensing and it's an LSD that uses Some accelerated gearing to Produce an impact instead of using clutch or fluid resistance lass

- It's used for race Cars and Performance cars

  1. reacts more quickly than LSD.

  2. Don't require regular maintenance.

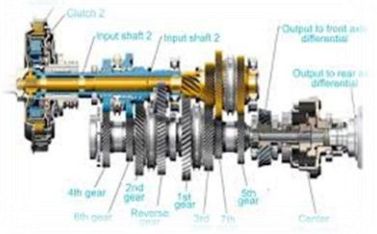
-It works like an open differential when wheel is in the air.

Welded differential.

-It's a type of locking differential it's usually done in Specific situations Like drifting.

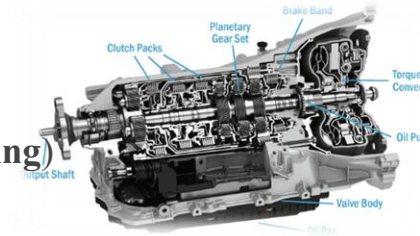
-Not recommended because the heat from Welding Can hazards the component strength. and increase the risk of Part failure.

02. List the different types of transmissions, then compare them in terms of design, operation, and applications.



Types of Transmissions

- Manual Transmission (**MT**)
- Automatic Transmission (**AT** – **torque converter type**)
- Automated Manual Transmission (**AMT**)
- Continuously Variable Transmission (**CVT**)
- Dual-Clutch Transmission (**DCT / DSG**)
- Semi-Automatic / Sequential Transmission (**used in racing**)



Comparison

Type	Design	Operation	Applications
- Manual Transmission (MT)	Gear sets with clutch operated by driver	Driver manually selects gears using clutch and gear lever	Economic cars, trucks, motorcycles; durable and low cost
- Automatic Transmission (AT)	Planetary gear sets + hydraulic torque converter	Gear shifting is automatic; fluid coupling replaces clutch	Passenger cars, SUVs, luxury vehicles; comfort and ease of driving
- Automated Manual Transmission (AMT)	Manual gearbox with automated clutch/shift actuators	Electronically controlled clutch + gear shift	Budget cars, commercial vehicles; cheaper than AT but less smooth
- Continuously Variable Transmission (CVT)	Pulley + belt/chain system, infinite ratios	Seamless ratio changes without fixed gears	Scooters, hybrid cars, some economy cars; good fuel efficiency
- Dual-Clutch Transmission (DCT/DSG)	Two clutches (odd/even gears) with mechatronic control	Very fast gear shifts, almost no power loss	Sports cars, premium cars, performance-oriented vehicles
Sequential Transmission	Like manual, but gears shift in sequence only	Quick gear changes using lever or paddle shifters	Motorsports, motorcycles, racing applications

03. Case Study: Research into Ayrton Senna's 1991 incident. Explain what happened in the accident, identify its main causes, and discuss possible solutions or preventive measures that could have been applied.

Senna's incident

I think the cause is

1.Steering Column failure.

2.differential gear broken

- My Solution is:

using more suitable material for design and some enhancements in design

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NOT Obligatory

01. Research and suggest a reliable brand or supplier for a sequential shifter hand, considering both quality and reasonable price, and make sure it is accessible or deliverable in Egypt.

02. Explain the advantages and disadvantages of CVT and determine if it's suitable for a formula student racing car.

CVT

Advantage:

faster getting shift in acceleration

Disadvantages:

in deceleration CVT makes a delay in gearing shifting

so, we Cannot use in our formula student car

Sources:

https://youtu.be/SvDcSFwyJhY?si=fyW8T7edsPj2bUPZ

https://youtu.be/mI4KlqsgqRI?si=pmTN8m6P63FNw8I2

https://youtu.be/emvBnP1nwqc?si=nz_B12-Zs0ZZ5zpV

Brakes Task:

01.Find out how pressing the brake pedal stops the car. Look up terms like hydraulic pressure, friction, brake pads, and rotors.

Ans

When we press the brake Pedal it makes a pressure in the hydraulic system, and the Pressure get amplified and. transfer to all the four wheels equally then it makes brake Pads make friction force with the rotors, so it stops the Car

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02. What is the component of the brakes system and write a brief about everyone?

1. Brake Pedal

It takes the pressure from driver's foot and transfers it to the hydraulic system.

2 Hydraulic system.

It takes the pressure from the brake pedal and modifies it and transfers it to all the wheels.
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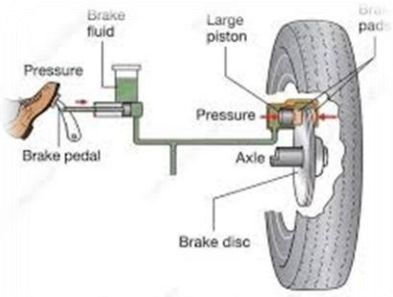

Hydraulic Braking System

3. Brake Pads.

Friction material that presses on the rotor to slow the car, made from ceramic, metallic or organic composites.

4. rotors (disk).

Metal disks attached to the wheel's pads clamp them to create a friction can be solid, ventilated, slotted, or drilled.

5. Calipers

Hydraulic units with pistons that push the pads against the rotors. types include Floating (simple) and fixed (performance)

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03. What are different types of brake rotors? Which one would you prefer? Why?

1. Ventilated rotors.

2. Drilled rotors.

3. slotted rotors.

If I would use one for a racing car it will be ventilated rotors because it has an improved heat rejection, and its angled vanes act like Pump evacuating heat from rotors

Sources:

https://www.youtube.com/watch?v=78wbht355R8

https://www.youtube.com/watch?v=6H7nwlT_qNY

04. The Menoufia Racing Team's electric vehicle had a brake failure during a test run. Your job is to figure out what caused the problem and how to prevent it from happening again. The vehicle experienced brake failure during a test run. It was going at high speed, and the weather was hot. The driver noticed reduced braking power and heard strange noises.

• What parts will you examine?

• Think, what could have caused the brake failure. Consider things like worn out parts, material defects, or design issues. ·

• Suggest ways to improve the brake system or maintenance procedures to avoid future failures.

I will examine Brake Pads

-I think the cause of the brake failure is that the brake Pads were worn out.

-The most important thing to do is Checking the brakes system every week to avoid something like that to happen again and we Can use material that Can Stand more time with high temperature.

Engine Task:

1-1. Explain the engine cycle.

Engine cycle is the repeated series of movement and thermodynamics processes that allow an engine to Produce work most commonly.

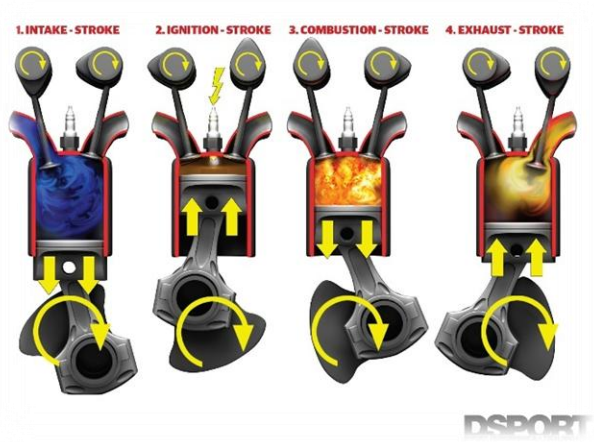
It has four strokes:

1. Intake stroke:

The Piston moves downward Opening the intake valve and drawing the air-fuel mixture into the cylinder.

2.Compression stroke:

The Piston moves upward with the valve Closed Compressing the air-fuel mixture.



3.Combustion stroke:

A Spark ignites the Compressed mixture Causing a powerful explosion that forces the Piston downward and generates Power.

4.Exhaust Stroke:

The piston moves upward again, opening the exhaust valve and pushing the burnt gases out of the Cylinder to make way for the next intake.

1-2. What is volumetric efficiency?

Volumetric efficiency measures of the actual amount of air that moves through the engine Comparing to that Engine Cubic Capacity.

1-3. How can it be improved, and how does it affect power and torque?

Volumetric efficiency can be improved by:

1.Using turbo Chargers and supercharges

To Pump more air into engine cylinder.

2.Using intercooling

To Cool the compressed air that enters combustion rooms to raise air density.

3.Using larger valves

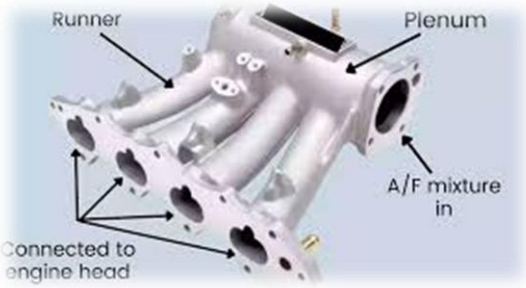
To enter the biggest amount of Compressed air we can Pump.

And of course, Volumetric efficiency directly increases Power and torque because more air allows more fuel to be burned.

2-1. What are the main parameters that affect the design of the intake manifold?

1.Runner geometry: Length and diameter

2.Air flow dynamics: minimize Pressure losses and ensure uniform flow to all Cylinder



3. Fuel delivery system: like injection

4. Plenum Volume and shape: balances air flow distribution, throttle response and high-speed breathing

5.Engine requirements: Placement and RPM henge

6.Material and manufacturing: Weight, heat transfer and Complexity of shapes

7. Packaging and thermal factors: to fit in engine bay and reduce heat Soak for denser air

2-2. Walk me through the design steps of the intake system.

1. **Define** your requirements and performance target like Peak RPM.
2. **Select** an appropriate engine and its Specifications to be suitable to your requirements.
3. **Airflow and Volumetric efficiency** analysis to estimate air demand Per cylinder.
4. **Runner and Plenum design** to design their Parameters.
5. **Air filters**: select your filters' size.
6. **Thermal management**: minimize heating of air intake.
7. **Integration and Packaging**: to fit in engine bay
8. **Simulation and Prototyping**: by CAD and CFD software.
9. **Validation and optimization**

3-1. What are the common methods used in designing the exhaust system?

1.Equal length headers:

To ensure uniform exhaust Pulse timing

2.tuned Primary Pipes

3.Collector design:

For smooth merging of runners

4.material Collection:

Stainless steel (light durable), mild steel(cheaper) and titanium (high performance)

5.Packaging: must fit in limited space

3-2. Compare a 4-2-1 and a 4-1 exhaust manifold.

TYPE	LAYOUT	PERFORMANCE	DISADVANTAGES
4-2-1 EXHAUST	4 pipes Merge into 2 pipes Merge into 1 pipe	1.Better mid-range torque 2.More suitable for engines that need drivability and flexibility	-Slightly less Peak Power at very high RPM Compared to 4-1 exhaust
4-1 EXHAUST	4 pipes Merge into 1 pipe directly	1. maximize top-end Power and high RPM Performance 2. Often used in racing where engines operate mostly at high RPM	-Weak low and mid-Range torque

3-3.Which one would you choose for our Formula Student car and why?

I Will Choose 4-2-1.

because it's good at mid-range torque which is suitable at formula Student.

SOURCES:

https://youtu.be/E96rBIzZ_sE?si=U74t_McZld4TwtbD

https://youtu.be/e72Xkf_5VXo?si=8HStep-uZgZcCYYa

Suspension Task

01.Types of load transfer, how it happens and how to calculate it with mentioning sources. (search)

1-lateral load transfer (while cornering)

Centrifugal Force = WAy

Where :

- ***W = Total vehicle mass***
- ***Ay = lateral acceleration in g***

$$W_L \times t = \left(W \times \frac{1}{2}\right) + (W \times A_y \times h)$$

Where:

- ***W_L = Static mass on left wheel (Kg)***
- ***t=track width (m)***
- ***W= vehicle total mass (Kg)***
- ***A_y = lateral acceleration in G***
- ***h=height of center of gravity (m)***

$$\Delta W = W_L - \frac{W}{2} = \frac{W \times A_y \times h}{t}$$

$$LLT = \frac{A_y \times h}{t}$$

2. Longitudinal load transfer (while acceleration or deceleration)

$$\Delta W_X \times L = h \times W \times A_X$$

Where :

- ΔW_X = The increase in the rear axle downward load and therefore the decrease in front axle load.Or if braking, it is the decrease in rear axle load and the increase in front axle load in Kg
- L=The wheel base of the car in meter
- h=the height of the center of gravity from th ground in meters
- W=total mass of the car in Kg
- A_X =Longitudinal acceleration in g fore

3-Vertical Load Transfer: it happens Due to bumps or road irregularities.

How to calculate:

Load transferred (N)= spring rate* vertical displacement+ damping coefficient* velocity of suspension compression.

02.When a car enters a corner, what forces act on it, and how do the loads react to those forces?

When a car takes a corner in a specific direction there are three forces that act on it:

In the same direction:

2 Cornering forces on each wheel (tire reaction force)

In the opposite direction:

Centrifugal force And the loads go in the opposite direction of Cornering.

03.A rear-wheel-drive car with mass 400 kg, trackwidth 1000mm for both front and rear, wheelbase 1400mm, cg height 50mm and wight distribution if 40 front to 60 rears. In two ways at least find:

a. The load transfer in acceleration if the acceleration is 40 m/s2.

b. the load transfer in corner if the deceleration is 10 m/s2and cornering radius is4 m.

NOTES:

- assume any lost data and mention it.
- mention any low that you used in calculation and the source of it.

Solution :

1st: W= 400 Kg , t = 1 m , L = 1.4 m, h = 0.05 m

w_f = 40% = 160 Kg , W_b = 60 % = 240 Kg

1- a = 40 m/s^2 A_x = 4.199

$$LLT = \frac{A_x \times h}{L} = \frac{4.19 * 0.05}{1.4} = 0.146$$

$L_F = 0.4 - 0.14 = 0.26$ Front wheels mass = 0.26 *400 = 104 Kg

$L_R = 0.6 + 0.14 = 0.74$ Reat wheels mass = 0.74 * 400 = 296 Kg

The transferred mass = 56 Kg

2nd : assume V = 10 m/s , assume we corner in the left

$$a_n = \frac{V^2}{P} = \frac{10^2}{4} = 25\ m/s^2\ , \qquad A_y = \frac{a_n}{g} = \frac{25}{9.8} = 2.69$$

$$\text{LLT} = \frac{A_x \times h}{L} = \frac{2.6 * 0.05}{1} = 0.13$$

$L_l = 0.5 - 0.13 = 0.37$ left wheels mass = 0.37 *400 = 148 Kg

$L_r = 0.5 + 0.13 = 0.63$ Right wheels mass = 0.63 * 400 = 252 Kg

The transferred mass = 52 Kg

04.In your opinion, why do some Formula Student cars choose a pushrod suspension while others use pull rod?

Mention one factor that affects the choice.

Compare the following systems in three points each:

1. Monotube vs Twin-Tube Dampers.

2. Pushrod vs Pull rod Suspension.

3. Passive vs Active Suspension.

Solution :

In my opinion choose pushrod because it is easier for maintenance.

COMPARISON:

Mono tube	Twin tube
1-easier cooling because the oil contact directly with outer shell.	1-weaker cooling because the oil on the tube.
2- ideal for racing car.	2-softer; smother;damping;ideal;for comfort in road cars.
3-complex design.	3-easier design.
4-More expensive.	4-cheaper.

pushrod	pull rod
1-easier to service and adjust.	1-harder to access.
2-higher center of gravity.	2- lower center of gravity.
3-less aero dynamics efficiency.	3-improved aerodynamics flow.

Passive suspension	Active suspension
1-use fixed mechanical component .	1-controlled electronically with used sensors.
2-low cost and simple.	2-expensive, complex.