Module 3: Assignment

Mechanical Subsystems of a Vehicle

Submitted by:

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Problem Statement:

You are a design engineer at a renowned automotive company specializing in developing high-performance sports cars. Your team has the task of optimizing various aspects of a new sports car model to ensure superior handling, braking, and overall performance on the track. As part of your responsibilities, you need to calculate and evaluate several key parameters related to steering, suspension, braking, and cooling system design.

Tasks to be Performed:

1. Steering ratio:

Given:
Steering wheel angle = 540 degrees (1.5 revolutions)
Wheel angle = 45 degrees

Solution:
Formula:
Steering Ratio = Steering Wheel Angle / Wheel Angle
= (540/45)
=12

Therefore, the steering ratio of the vehicle is 12. This means that for every 12 degrees of rotation of the steering wheel, the wheels turn 1 degree.

2. Steering effort calculation (Total Kingpin Torque Required to steer an axle):

Given:
Weight on the axle (W) = 800 kg
Friction coefficient (f) = 0.15
Track width (B) = 1.5 m
Effective radius (E) = 0.4 m

Solution:
Formula:
$T = W * f * \sqrt{((B^2 / 8) + E^2)}$
$= 800*0.15* \sqrt{((1.5)^2 / 8) + (0.4)^2)}$
$=120*\sqrt{((2.25/ 8) + (0.16)}$
$= 120*\sqrt{(0.28) + (0.16)}$
$= 120*\sqrt{(0.44)}$
$= 120*0.66$
$= 79.2$ Nm

Therefore, the total kingpin torque required to steer an axle is approximately 79.2 Nm.

3. Stiffness of a spring or suspension

Given:
Force applied (F) = 2000 N
Displacement (Δx) = 0.05 m

Solution:
Formula:
$k = F / \Delta x$
$= 2000/0.05$
$= 40000$

Therefore, the stiffness of the suspension system is 40000 N/m.

4. Braking Force

Given:
Friction coefficient (μ) = 0.8
Normal force (Fn) = 1500 N

Solution:
Formula:
Braking Force = 2 * μ * Fn
= 2*0.8*1500
= 2400 N

Therefore, the braking force exerted on the sports car is 2400 Newtons.

5. Total Load acting on Chassis

Given:
Weight of chassis frame = 1200 kg
Weight of persons = 400 kg
Weight of other components = 300 kg

Solution:
Formula:
Total Load on Chassis = Weight of Chassis Frame + Weight of Persons + Weight of Other Components
= 1200+400+300
= 1900 kg

Therefore, the total load acting on the chassis of this electric vehicle is 1900 kilograms.

6. Speed ratio

Given:
Max speed = 300 km/h
Base speed = 100 km/h

Solution:
Formula:
Speed Ratio = Max speed / Base speed
= 300/100
= 3

Therefore, the speed ratio for this mechanical system is 3.

7. Volume of PCM in Cell

Given:
Latent heat of fusion of PCM (L) = 200,000 J/kg
Density of PCM in cell (ρ) = 1000 kg/m^3
Power absorbed (P) = 5000 W
Time of power absorption (t) = 1800 seconds

Solution:
Formula:
V * ρ * L = P * t
V = p * t / ρ*L
= 5000*1800 / 1000 * 200,000
= 0.045 m^3

Therefore, the volume of the PCM in cell is 0.045 m^3.

8. Toe Alignment

Given:
Front Tire Distance = 1.2 m
Rear Tire Distance = 1.15 m

Solution:
Formula:
Toe Alignment = Front Tire Distance - Rear Tire Distance
= 1.2 – 1.15
= 0.05 m

Therefore, the toe alignment of the vehicle is 0.05 m. This positive value indicates that the front of the tires is wider apart than the rear, which is known as toe-in alignment.