MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
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DEPARTMENT OF MECHATRONICS
VI SEMESTER B.TECH. MECHATRONICS
END SEMESTER EXAMINATION, MAY 2024
SUBJECT: Vehicle Dynamics **Subject Code: MTE 4054**
Date: 06/05/2024
Time: 180 Mins **Exam time: 2:30 pm – 5:30 pm** **MAX. MARKS: 50**

- Answer **ALL** questions.
- Missing data if any, maybe suitably assumed.

<table>
<tr><th>Q. No.</th><th></th><th>M</th><th>CO</th><th>PO</th><th>LO</th><th>BL</th></tr>
<tr><td>1A.</td><td>A passenger car weighs 20.105 kN and has a wheelbase of 2.8 m. The weight distribution on the front axle is 53.5%, and that on the rear axle is 46.5% under static conditions.

a) If the cornering stiffness of each of the front tires is 38.92 kN/rad and that of the rear tires is 38.25 kN/rad, determine the steady-state handling behavior of the vehicle.

b) If the front tires are replaced by a pair of radial-ply tires, each of which has a cornering stiffness of 47.82 kN/rad and the rear tires remain unchanged, determine the steady-state handling behaviour of the vehicle under these circumstances.</td><td>5</td><td>4</td><td>2</td><td>2</td><td>3</td></tr>
<tr><td>1B.</td><td>Consider an accelerating car on a level road as shown in Figure 1B. Determine the vertical forces acting on the front and rear wheels. (Neglect the aerodynamic, d Alembert’s force, and braking force.)

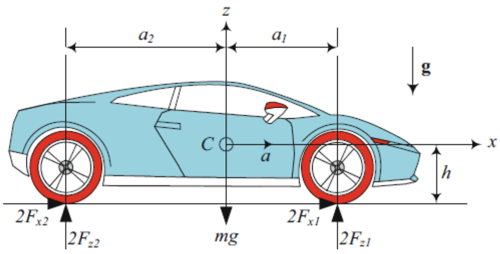
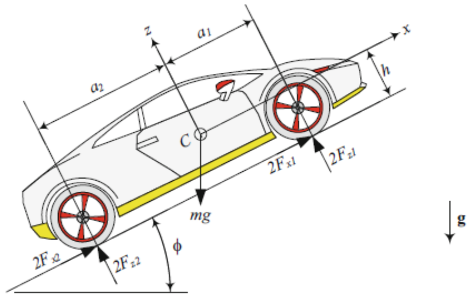


Fig.1B</td><td>3</td><td>1</td><td>2</td><td>2</td><td>4</td></tr>
<tr><td>1C.</td><td>Explain the concept of the roll, pitch, and yaw motions for the vehicle. Along which axis the centrifugal and centripetal forces will act?</td><td>2</td><td>4</td><td>4</td><td>4</td><td>2</td></tr>
<tr><td>2A.</td><td>Consider a parked car on an uphill road (Figure 2A). If the forces under the front and rear wheels are F_{z1} and F_{z2}, then prove that the inclined angle of the road is:
$$\phi = \arctan\left(\frac{a_2 - a_1\left(F_{z_1}/F_{z_2}\right)}{h + h\left(F_{z_1}/F_{z_2}\right)}\right)$$</td><td>5</td><td>1</td><td>2</td><td>2</td><td>4</td></tr>
</table>

	 ***Fig. 2A*** (Neglect the aerodynamic, d Alembert's force, and braking force.)					
2B.	Consider a car with the following characteristics: Wheelbase = 2272 mm; the center of gravity is at the center of the car and has a height of 220 mm above the ground level. If the coefficient of friction, $\mu_x = 1$, and the mass of the car, m = 1500 kg. Calculate the minimum time required to reach the speed of 0 – 100 km/hr, assuming that the car is a rear-wheel drive car.	**3**	**1**	**2**	**2**	**3**
2C.	A car is parked on a level road. Determine the force on front and rear axles, if m = 1665 kg, wheelbase = 2.48 m, the distance between front wheels and center of gravity is 1.35 m. (Neglect the aerodynamic, d Alembert's force, tractive and braking forces, and rolling resistance forces.)	**2**	**1**	**2**	**2**	**3**
3A.	Explain the conicity and ply steer effect in a tire.	**4**	**2**	**4**	**4**	**2**
3B.	A sports car weighs 9.919 kN and has a wheelbase of 2.26 m. The center of gravity is 1.13 m behind the front axle. The cornering stiffness of each front tire is 58.62 kN/rad and that of each rear tire is 71.36 kN/rad. Determine the steady-state yaw velocity gain and lateral acceleration gain of the vehicle. The forward speed of the vehicle is 90 km/hr.	**3**	**4**	**2**	**2**	**3**
3C.	Derive an expression for Ackermann Steering Geometry.	**3**	**4**	**4**	**4**	**3**
4A.	A passenger car weighs 21.24 kN and has a wheelbase of 2.87 m. The center of gravity is 1.27 m behind the front axle and 0.508 m above the ground level. The braking effort distribution on the front axle is 60%. The coefficient of rolling resistance is 0.02. Determine which set of tires will lock first on a road surface when the coefficient of road adhesion is: i. $\mu = 0.8$ and ii. $\mu = 0.2$.	**5**	**1**	**2**	**2**	**3**
4B.	For steady-state handling characteristics of a two-axle vehicle represented as a Bicycle Model, derive the expression for cornering forces and slip angles for front and rear wheels.	**3**	**4**	**4**	**4**	**3**
4C.	Explain anti-squat and anti-dive suspension geometry.	**2**	**1**	**4**	**4**	**2**
5A.	The sprung parts of a passenger car weigh 11.12 kN and the unsprung parts weigh 890 N. The combined stiffness of the suspension springs is 45.53 kN/m and that of the tires is 525.35 kN/m. Compute the natural frequencies of the bounce motions of the sprung and un-sprung masses. Also, calculate the amplitudes of the sprung and un-sprung parts if the car travels at a speed of 48 km/h over a road of a sinewave form with a wavelength of 9.15 m and an amplitude of 5 cm.	**5**	**1**	**2**	**2**	**3**

5B.	In what way do the wheels of a car (front and rear) get locked up? Why does the rear wheel lockup be a critical situation, particularly on a road with a low coefficient of adhesion?	**3**	**1**	**4**	**4**	**2**
5C.	Explain the ISO 2631 standard for the evaluation of vibrational environments in transport and industry vehicles.	**2**	**1**	**4**	**4**	**2**