Name: **Enrolment No:**	UPES University of Tomorrow

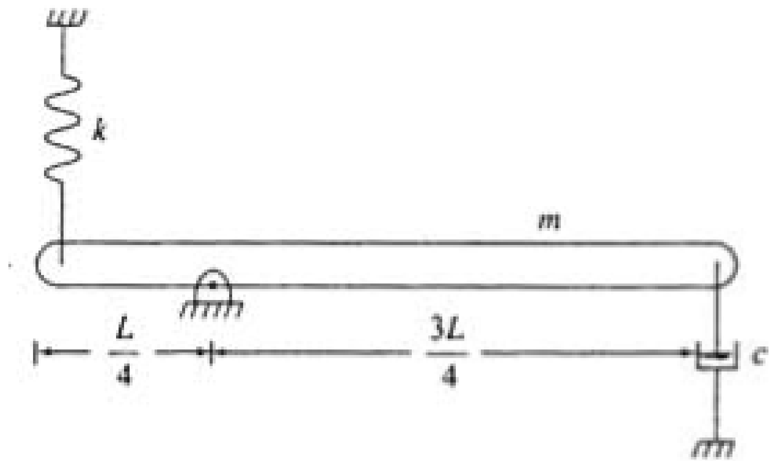
UPES

End Semester Examination, December 2023

Course: **Vehicle Dynamics** — **Semester: I**
Program: **M.Tech E-Mobility** — **Time: 03 hrs**
Course Code: **MEEM7003** — **Max. Marks: 100**

Instructions: Wherever applicable, must draw appropriate free body diagram and work with symbols before substituting numerical values.

S. No.		Marks	CO
	SECTION A (5Qx4M=20Marks)		
Q 1	Explain the response of an underdamped system for free vibrations and logarithmic decrement.	**4**	**CO1**
Q 2	Explain slip angle. Discuss why it is required during turning?	**4**	**CO1**
Q 3	Explain various sources that cause vibrations in a vehicle.	**4**	**CO1**
Q 4	Explain the 'angle of rolling down' for a passenger car parked on a banked road along with formula. (Note: road is not inclined but is banked)	**4**	**CO1**
Q 5	Analyze the behavior of an oversteer and understeer vehicle by plotting 'steer angle vs speed' curve for both. Analyze how the steer angle should be changed for each while negotiating a constant radius curve if the driver also accelerates during the turn.	**4**	**CO2**
	SECTION B (4Qx10M= 40 Marks)		
Q 6	A car with mass = 1500 kg, wheel base = 3 m, has 60% of weight distribution on front tires. Lateral stiffness of front and rear tires is $C_f = 40\ kN/rad$ and $C_r = 45\ kN/rad$. Calculate the understeer coefficient and critical speed or characteristic speed as applicable.	**10**	**CO3**
Q 7	Analyze the reason for rolling resistance. Also derive an expression for effective radius (also called rolling radius) of tire.	**10**	**CO2**
Q 8	A car has 55% of static load on the rear axle. The ratio of height of CG to wheel base, h/L=0.2. Coefficient of friction $\mu = 0.8$, coefficient of rolling resistance $f_r = 0.01$. Determine the ideal brake force distribution for which the system should be designed. (That is K_{bf} and K_{br})	**10**	**CO3**
Q 9	Design a suitable vibration absorber for a machine that has mass of 50 kg and runs at 6000 rpm. Its forcing frequency is very near to its natural	**10**	**CO3**

	frequency. The nearest natural frequency of the 2 DOF system is to be at least 20% from the forced frequency. **OR** Determine the parameters in an equivalent system model of the system when θ, the clockwise angular displacement of the bar from the system's equilibrium position, is used as the generalized coordinate. 		
SECTION-C **(2Qx20M=40 Marks)**			
Q 10	Gopal, as a dedicated cop, is doing his best to chase a suspect. He is driving a 'rear wheel drive' car uphill and using the maximum available traction. He is only able to accelerate at 1 m/s^2. The relevant data is the following – Mass of car, m = 1000 kg Slope angle, $\theta = 15^o$ Speed, v = 10 m/s Car frontal area, $A_f = 2\ m^2$ Coefficient of drag, $C_D = 0.3$ Coefficient of rolling resistance, $f_r = 0.01$ Wheel base, L = 3 m Distance of CG from front axle, l_1 = 1.5 m Height of CG, h = 0.3 m Use g = 10 m/s^2 Assume aerodynamic drag is acting on CG and density of air is 1.2 kg/m^3. Determine/do (a) Draw a FBD showing all forces (b) The load on front and rear axle	**20**	**CO4**

	(c) The available traction force (d) Evaluate the coefficient of friction at road-tire interface. Analyze if the value is reasonable.		
Q 11	A vehicle is modeled using a quarter car model. The relevant data is the following – Sprung mass, $m_s = 2000\ kg$ Unsprung mass, $m_{us} = 200\ kg$ Suspension system stiffness, $k_s = 100\ kN/m$ Tire stiffness, $k_t = 1000\ kN/m$ Damping coefficients c_s, c_t are negligible. (Use them in the formulation and eventually make them zero). Determine the natural frequencies using (a) matrix method and (b) approximate method and compare them. **OR** A vehicle is modeled using the pitch & bounce model. The relevant data is the following – Sprung mass, $m_s = 2000\ kg$ Radius of gyration, $r_y = 1.25\ m$ Distance from front axle to CG = 1.25 m Distance from rear axle to CG = 1.5 m Front spring stiffness, $k_f = 35\ kN/m$ Rear spring stiffness, $k_r = 40\ kN/m$ Determine/Do (a) Derive the equations of motion for the 2 DOF system (b) Determine the natural frequencies and mode shapes (c) Calculate the locations of oscillation centers	**20**	**CO3**