Name: Enrolment No:	

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2018

Course: Vehicle Dynamics **Semester: V**
Programme: B Tech (ADE)

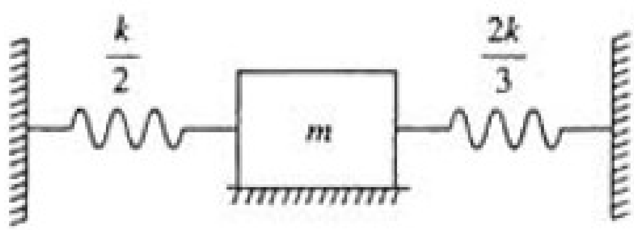
Time: 03 hrs.
Max. Marks: 100

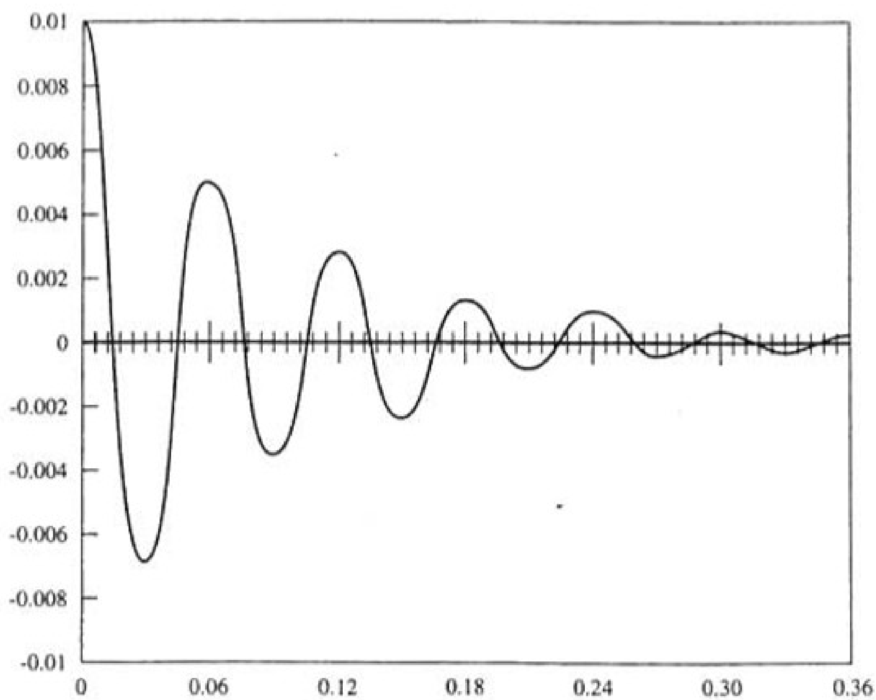
Instructions: If data is insufficient, make relevant assumptions and state the same.

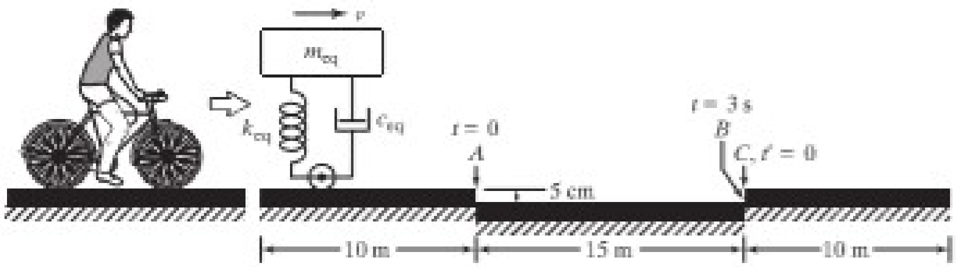
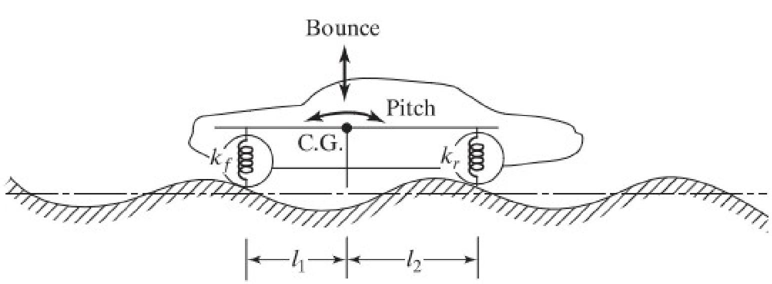
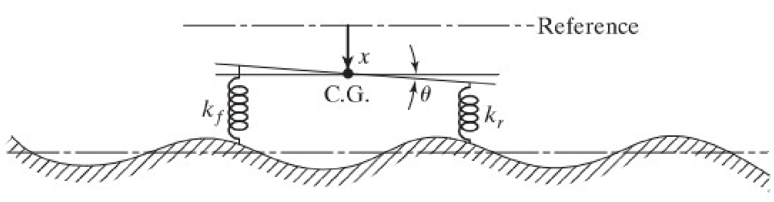
SECTION A

S. No.		**Marks**	**CO**
Q 1	**Select the correct Option**	**0.5*8 = 4**	**CO1 CO2**
A	A physical system with 4 Degree of freedom will have ---- independent equations in its mathematical model. a) 2 b) 4 c) 1 d) None of above		
B	The reduction of the amplitude ratio in the presence of damping is very significant when a) $\omega_n = \omega$ b) $\omega_n > \omega$ c) $\omega_n < \omega$ d) None of the above		
C	Glass transition temperature of a visco-elastic material represents a) The transition from hard and brittle form to soft and rubbery form. b) The transition from viscous to elastic form c) The transition from crystalline phase to amorphous phase d) The melting point of visco-elastic material		

D	Tire slip refers to a) Dynamic hydroplaning b) Rubber hydroplaning c) Castor and camber angle d) Direction of tire relative to direction of vehicle velocity		
E	Maximum force in contact patch is experienced when a) Tires are rolling with 0.15 to 0.30 slip b) Tires are locked c) During free rolling with zero slip d) When tire is sliding		
F	For a passenger car running at high speeds the drag force will aid in a) Reducing the stopping distance b) Increasing the stopping distance c) Increasing the maximum velocity attained d) Reducing the time to attaining maximum velocity		
G	Wings are used in sports car for a) Improving aesthetics b) Increasing positive lift c) Increasing the negative lift d) To help in cornering		
H	A positive roll steer on rear axle will result in a) Under steer b) Ply steer c) Over steer d) Neutral steer		
Q 2	**State True / False**	**0.5*8 = 4**	**CO1 CO2**
A	Will the spring constant remain constant for two rods with same weight, area of cross section and made of same material?		
B	The amplitude of an undamped system will not change with time.		
C	Larger tires are provided in tractors for better traction and higher velocity		
D	In tires side wall bending give rise to uniform pressure distribution in contact patch		
E	The maximum acceleration possible in a car is equal to 9.8 m/s^2. (Assume μ=1)		
F	Raising the height of CG from ground increases the maximum possible acceleration in a rear wheel drive passenger car		

G	The under tray provided in car increases the turbulence of air leading to reduced positive lift		
H	Banking is provided on roads to have increased stability while cornering.		
Q 3	**Write one word or sentence**	**1*4=4**	**CO1 CO2**
A	What is meant by tilting angle in context of forward vehicle dynamics?		
B	The primary components contributing the rolling resistance of a tyre are ----- and -----.		
C	For studying the stress relaxation behavior of rubber which mathematical model do you prefer?		
D	What is the function of front and rear diffusers provided in racing cars?		
Q 4	Write short answers	**2*2=4**	**CO1 CO2**
A	What is the function of spoilers used in racing cars?		
B	What are the assumptions used in quarter car model?		
Q 5	Write the formula and solution.	**2*2=4**	**CO3**
A	Find the natural frequency of the given system 		
B	The curb weight of a Continental 4 door sedan, without passengers are 1050 kg on the front axle and 750 kg on rear axle. The wheelbase is 2752 mm. Determine the fore and aft position of the center of gravity for the vehicle.		
	SECTION B		
Q 1	A 500-kg vehicle is mounted on two parallel springs such that its static deflection is 1.5 mm. What is the damping coefficient of a viscous damper to be added to the system in parallel with the springs, such that the system is critically damped	**10**	**CO3 CO4**
Q 2	Mercedes-Benz C 300 with a 2 liter 4-cylinder engine has a max power of 241 HP @ 5550 and max torque of 273 lb-ft @ 1300 rpm. The vehicle is rear wheel driven and has an aerodynamically designed body having a drag coefficient of 0.29. Calculate the maximum possible speed that can be achieved by the car assuming the density of air is 1.25kg/m^3. Also calculate the minimum time required for the car to reach 100 km/h on a level road from rest and the time to reach maximum velocity by considering the drag force. The specifications of the car is given below. – Length = 184.5” – Width = 71.3” – Height = 56.8”	**10**	**CO4**

	– Wheel base = 111.8” – Front track = 61.5” – Rear track = 60.9” – Height of CG = 20” – Curb weight weight front= 750 kg – Curb weight weight rear = 1270 kg		
Q 3	During Formula 1 racing, it was observed that the car was lifted off the ground when it was speeding. Discuss the possible reasons for the phenomenon and suggest suitable solutions to avoid lifting without sacrificing the lap time.	**10**	**CO4**
Q 4	A free vibrations test is run to determine the stiffness and damping properties of an elastic element. A 20-kg block is attached to the element. The block is displaced 1 cm and released. The resulting oscillations are monitored with the results shown in Fig. Determine the stiffness and damping of the elastic element. 	**10**	**CO3** **CO4**
	OR		
	A boy riding a bicycle can be modeled as a spring-mass-damper system with an equivalent weight, stiffness, and damping constant of 900 N, 55,000 N/m, and 1,500 N-s/m, respectively. The differential setting of the concrete blocks on the road caused the level surface to decrease suddenly, as indicated in Fig. If the speed of the bicycle is 20 km/hr, determine the displacement of the boy in the vertical direction. Assume that the bicycle is free of vertical vibration before encountering the step change in the vertical displacement.	**10**	**CO4**

			
SECTION-C			
Q 1	**Answer the following**	**2*10 = 20**	**CO3**
A	Discuss the variation of velocity, pressure distribution and force in contact patch with the help of a neat diagram.		
B	Analyse the significance of tire brush model in contact patch force development. Derive the expression for total lateral force developed in contact patch while the vehicle is making a turn using tire brush model.		
Q 2	An automobile is modeled with a capability of pitch and bounce motions, as shown in Fig. It travels on a rough road whose surface varies sinusoidally with an amplitude of 0.035 m and a wavelength of 7.5 m. Derive the equations of motion of the automobile for the following data: Radius of gyration = 1.2 m Velocity = 50 km/hr. Location of CG from front axle = 1015 mm Location of CG from rear axle = 1240 mm Stiffness of front tire and suspension = 20 kN/m Stiffness of rear tire and suspension = 16 kN/m Also calculate the pitching and bouncing frequency of the car in motion  (a) 	**20**	**CO4**

	OR		
	A car has a weight of 650 kg on front axle and 550 kg rear with a wheel base of 2752 mm wheel base. The tires have the following cornering stiffness values (see table below). Determine the following cornering properties for the vehicle. a) Ackerman steer angle for 500, 200, 100 and 50 ft turn radius. b) Under steer gradient c) Characteristic speed d) Lateral acceleration gain at 75 km/hr e) Yaw velocity gain at 75 km/hr f) Side slip angle at CG on a 750 ft turn at 75 km/hr	**20**	**CO4**

Load	Cornering stiffness	Cornering Coefficient
50 kg	30 kg/deg	0.298
100 kg	60 kg/deg	0.268
150 kg	80 kg/deg	0.252
250 kg	100 kg/deg	0.223
400 kg	120 kg/deg	0.218