Name: Enrolment No:	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2019

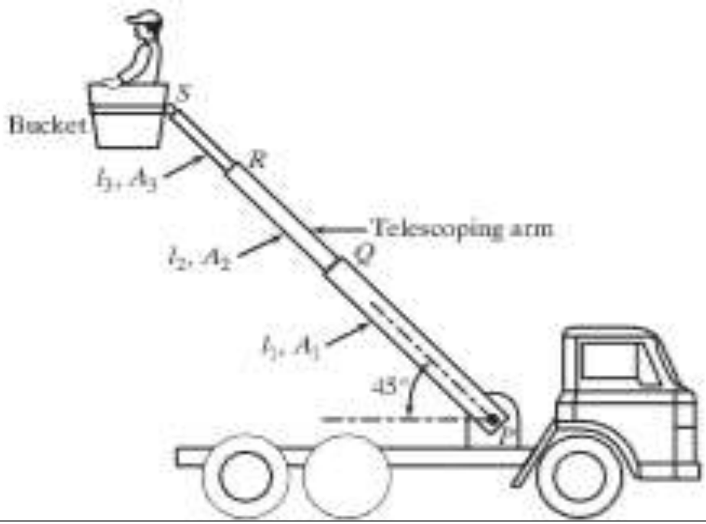
Course: **Vehicle Dynamics** **Semester: V**
Program: **ADE** **Time 03 hrs.**
Course Code: **MEAD3001** **Max. Marks: 100**
No of pages : **4**
Instructions: **If data is insufficient, make relevant assumptions and state the same.**

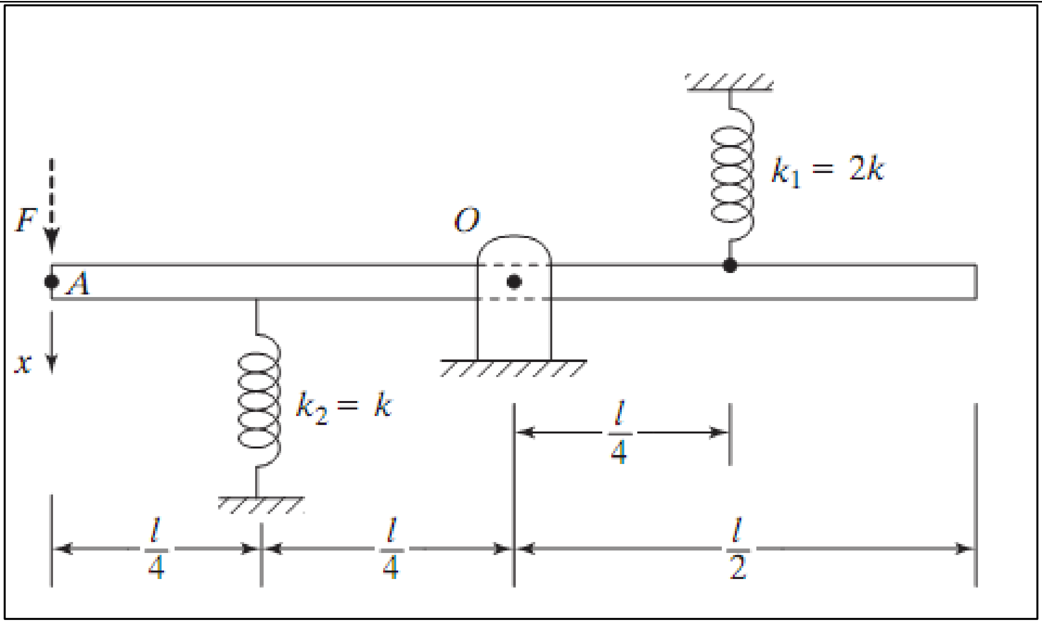
SECTION A (20 Marks)

S. No.		**Marks**	**CO**
Q 1a	The primary component of tire rolling resistance in inflated tire results from a) Micro sliding of tyre on road surface b) Energy dissipation by hysteresis loss c) Lateral slip angle in tire d) Resistance offered by air drag	**1**	**CO3**
b	Maximum acceleration or deceleration attained by a 4 Wheel drive passenger car on level road is a) μg b) μgb/(L-hμ) c) μgc/(L-hμ) d) μgc/(L+hμ)	**1**	**CO6**
c	The spring constant of a cantilever beam with an end mass m is 3EI/l3 b)l3/3EI c) Wl3/3EI d)l2/3EI	**1**	**CO1**
d	Gradient resistance for a vehicle depends on which of the following factors a) Weight of the vehicle b) Size of the vehicle c) Width of tyres d) Speed of the vehicle	**1**	**CO6**
e	The manufacturing tolerances affects the ------- of tires a) Conicity b) Ply steer c) Slip d) Tire stiffness	**1**	**CO3**
Q 2 a	Draw the creep, relaxation and recovery response of tire (rubber) using Maxwell and Kelvin-Voigt Models	**5**	**CO3**
b	What is meant by static and dynamic coupling? How can you eliminate coupling of the equations of motion?	**5**	**CO1**
c	While driving in rain, it is safer to have low air pressure in passenger car tires. State true or false and justify your answer	**5**	**CO3**

SECTION B (40 Marks)

Q 3	A railroad bumper is designed as a spring in parallel with a viscous damper. What is the bumper's damping coefficient such that the system has a damping ratio of 1.25 when the bumper is engaged by a 20,000-kg railroad car and has a stiffness of 2 x 10^5 N/m?	**10**	**CO5**
Q4	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**	**CO6** **CO2**

Q5	Analyse the significance of tire brush model in contact patch force development in cornering. Derive the expression for total force developed in contact patch using tire brush model.	**10**	**CO3**
Q6	Find the natural frequency of the cockpit in fire truck as shown. The weight of the cockpit weighs 150 Kg. Assume the weight of person doing the service is 75 Kg. Consider the telescopic arm is made of steel with an young's modulus of 200 GPa with following dimensions. Base arm = l_1=4m, A_1=20 cm^2; Intermediate arm l_2=3 m, A_2=10cm^2; Top arm l_3=2m, A_3=5cm^2 	**10**	**CO1**
	OR		
Q6	The static equilibrium position of a massless rigid bar, hinged at point O and connected with springs k1 and k2 is shown in Figure. Assuming that the displacement (x) resulting from the application of a force F at point A is small, find the equivalent spring constant of the system ke, that relates the applied force F to the displacement x as F = ke x.	**10**	**CO1**



SECTION-C (40 Marks)

Q 7 (20 marks; CO6, CO2)

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.

a) Calculate the maximum possible speed that can be achieved by the car by considering drag assuming the density of air is 1.15kg/m^3. Also calculate the time needed to achieve this speed.

b) Calculate the minimum time required for the car to reach 100 km/h on an inclined road with a gradient of 12%from rest (assume μ=0.75).

c) Calculate the speed at which the car will be lifted from the ground (Assume pressure under the car remains at atmospheric pressure)

The specifications of the car is given below.

- Length = 184.5” Width = 71.3”
- Height = 56.8” Wheel base = 111.8”
- Front track = 61.5” Rear track = 60.9”
- Height of CG = 20” Curb weight weight front= 750 kg

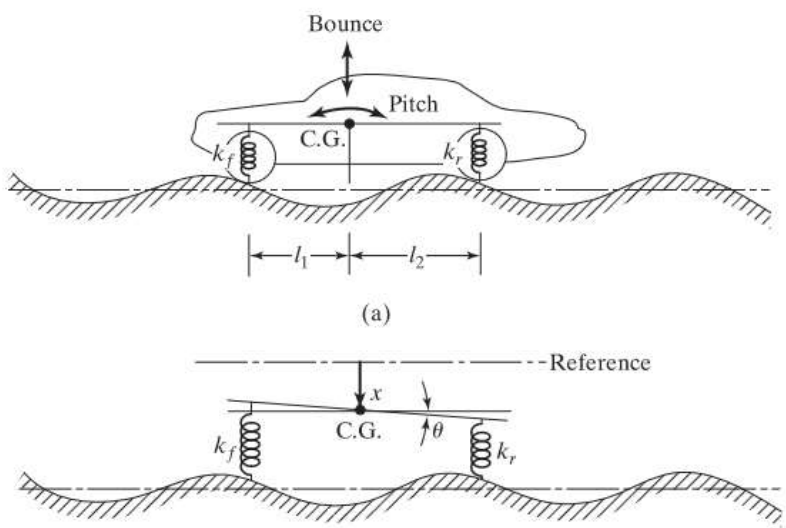
Curb weight weight rear = 1270 kg

Q8 (20 marks; CO1, CO4, CO6)

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

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

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 Side slip angle at CG on a 750 ft turn at 75 km/hr		
	OR		
Q8	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 	**20**	**CO1** **CO4** **CO6**