ELIZADE UNIVERSITY, ILARA-MOKIN, ONDO STATE, NIGERIA

DEPARTMENT OF AUTOMOTIVE ENGINEERING

SECOND SEMESTER EXAMINATIONS

2017/2018 ACADEMIC SESSION

HOD'S SIGNATURE

COURSE: ATE 304 – **VEHICLE DYNAMICS AND CONTROL - I**

(3 Units)

CLASS: 300 Level Automotive Engineering

TIME ALLOWED: 3 Hours

INSTRUCTIONS: Answer **Question 1** and **any other three questions** (from Qu. 2 – Qu. 6).

Date: July/August, 2018

Question 1

i. Define degree of freedom (DoF) of a dynamical system
ii. Define generalized coordinate for dynamical systems
iii. Draw neat sketches of SAE Axis system and Vehicle Earth Coordinate system
iv. Identify the types of motion associated with the coordinate axes, giving their names and showing their directions in the positive sense for both translational & rotational motions
v. State the four-step approach for handling problems of vehicle dynamics
vi. State the vector form of the equations of motion (EoM) of a rigid body comprising translational and rotational motions
vii. With ref to the two sets of coordinate systems in (iii), explain the use of the vector relation: $\frac{dA}{dt} = \frac{\partial A}{\partial t}\Big|_{rel} + \omega x A$, where A is any vector associated with rigid body motion and ω is angular velocity.
viii. Define tyre slip angle. Use a sketch for illustration.
ix. State three main features of high speed cornering in vehicle motion
x. Define cornering stiffness and camber stiffness
xi. State three main characteristics of steady state vehicle cornering
xii. Explain the effect of slip angle on lateral force.

Question 2

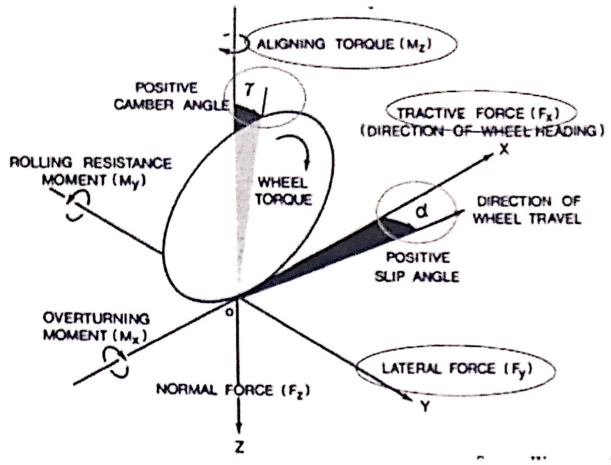

Figure 1

Figure 1 above shows elements for describing tyre mechanics. Do the following:

a) State the names of O, X, Y, Z
b) Explain why the positive senses of the slip angle α and camber angle γ are as shown
c) Draw sketches to show the camber angle alone in the views along the X-axis and Y-axis, indicating the possible swivel position

Question 3

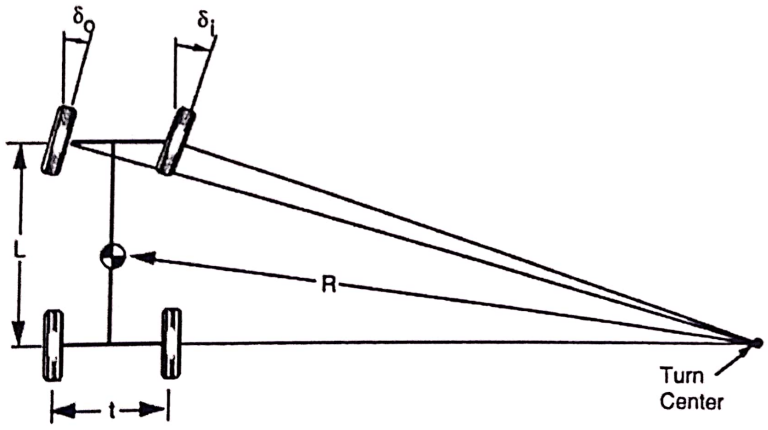

Figure 2

Figure 2 above shows the Ackerman geometry for low speed turning of a four-wheel vehicle. Do the following:

a) Identify the parameters shown, stating their names
b) State the assumptions involved in the Ackerman model for low speed turning

c) Using the geometry in Figure 2, derive expressions for the steer angles δ_o and δ_i in terms of R, L and t

d) Show that for small angles, the average steer angle is $\delta_{ave} = \frac{L}{R}$ approx.

Question 4

Explain the (i) function, (ii) operation and (iii) limitations of any three of the vehicle control systems listed below here. Draw sketches or diagrams where appropriate.

a) Engine control unit (otherwise known as 'brain box')
b) Electronic clutch control (ECC)
c) Anti-lock / Anti-skid braking system (ABS)
d) Traction control systems (TCS)

Question 5

Define a vehicle suspension system

State three functions of a vehicle suspension system

There are three types of vehicle suspension system, namely: (i) dependent, (ii) semi-dependent and (iii) independent. With the aid of appropriate sketches, describe the features of any two of them.

Question 6

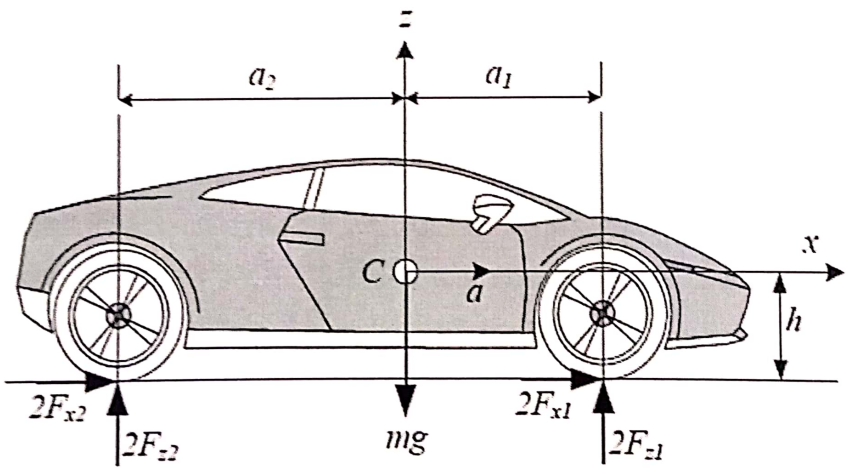

Figure 3

Figure 3 above shows the free body diagram of a car accelerating (forward) on a level road. Do the following

a) Identify each of the elements shown

b) State the equations of motion for this two-dimensional model of translational and rotational motion with respect to the center of mass, C

c) Let mass of the car = 890 kg. C is located 78 cm from the front wheel axis and the wheel base is 235 cm. If the car is parked (i.e. stationary), calculate the forces under each front and rear wheel.