



UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022

COURSE NAME : VEHICLE DYNAMIC

COURSE CODE : BNG 32003

PROGRAMME CODE : BNG

EXAMINATION DATE : JULY 2022

DURATION : 3 HOURS

INSTRUCTION : 1. ANSWER **ALL** QUESTIONS

2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK**.

3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

THIS QUESTION PAPER CONSISTS OF **FOUR (4)** PAGES

- Q1** (a) The vehicle driving dynamics is divided into longitudinal, vertical and lateral dynamics, which includes several driving motion.
- (i) Describe the definition of vehicle dynamic in terms of vehicle motion and its behavior. (6 marks)
- (ii) Draw and derive an equation on how forces act on the drum brake shoes. (5 marks)
- (b) The behavior of the tire plays an important role in controlling the horizontal motion of the vehicle. In vehicle dynamics studies, a good representation of tire behavior is a necessary. In automotive, tires are designed to support the vehicle weight, absorb road vibration and other two functions.
- (i) List **TWO (2)** other tire functions. (2 marks)
- (ii) Explain **TWO (2)** primary mechanisms responsible for friction coupling between tire and road friction. (4 marks)
- (c) Ahmad took his vehicle to the vehicle service center because the antilock brake system warning light kept blinking during driving. Unfortunately, the light does not appear during checking, and the vehicle problem cannot be diagnosed. A few days later, Ahmad had an accident during heavy rain. It was presumed that the antilock brake system was failed.
- (i) Explain the working principle of the Antilock Brake System with drawing aids. (4 marks)
- (ii) Diagnose and explain **TWO (2)** possible cause of the accident which relate to the antilock brake system. (4 marks)
- Q2** (a) Bernoulli Equation can be considered to be a statement of the conservation of energy principle appropriate for flowing fluids. Explain the movement of air flow around the vehicle by using the relationship of velocity and pressure expressed in Bernoulli's Equation. (4 marks)
- (b) Aerodynamic drag is a force which the oncoming air applies to a moving body. It is the resistance offered by the air to the movement of the body. So, when a car is moving, it displaces the air. Based on the aerodynamics concept, describe the effect of flow separation from an automotive point of view (3 marks)

- (c) Aerodynamic drag separated into three conditions, which are forebody drag, bumper spoiler drag and windshield drag. Elaborate windshield effect on driving condition based on aerodynamic drag. (3 marks)
- (d) Rolling resistance is the combination of forces that work against the forward motion of your vehicle. Derive rolling resistance equation during:
- (i) tire stationary and; (2 marks)
- (ii) tire rotating condition. (7 marks)
- (e) As an automotive engineer, suggest **ONE (1)** method for each moment that can reduce the aerodynamic effect in pitching, yaw and rolling moment. (6 marks)
- Q3**
- (a) One of the very known and useful model to study the vehicle's comfort and stability is the quarter-car model suspension system. With an appropriate diagram, derive a quarter car suspension system model which represents sprung acceleration, \ddot{x}_1 and unsprung acceleration, \ddot{x}_2 . (6 marks)
- (b) Ackerman Steering concept is always being used to analyze the low-speed turning behavior of a vehicle. Explain **TWO (2)** importance of Ackerman Steering geometry and draw its diagram. (4 marks)
- (c) Steady-state cornering equations are derived from the application of Newton's Second Law along with the equation geometry during vehicle turning. Using the cornering equation, calculate the summation of lateral force (front and rear tires) during cornering on Universiti Tun Hussein Onn (Pagoh branch) roundabout which is about 0.01 km in radius. The vehicle was driving with a forward velocity of 20 km/h with the vehicle's kerb weight of the vehicle is 1221 kg, and the driver weighted at 77 kg. Convert the final value of force in unit kilogram. (5 marks)
- (d) Tire slip angle is a part of an important parameter which to improve vehicle handling. Define the slip side angle of the tire with drawing aid and explain the effect on lateral force and slip angle. (4 marks)
- (e) Understeer and oversteer are vehicle dynamics terms used to describe the sensitivity of a vehicle to steering. With the aid of an appropriate diagram, show the definition of understeer in an automotive application. (2 marks)

- (f) The roll motion is a direct feature of vehicle moment on its longitudinal direction. Identify **TWO (2)** possible parameters which can be improved in the event of a vehicle roll moment.

(4 marks)

- Q4** (a) A vehicle axle is the steel rod that connects the left and right of the wheel, or front and rear vehicle. Solid axle is also known as beam axle or solid axle.

- (i) Explain the function of the solid axle in the vehicle.

(2 marks)

- (ii) State **TWO (2)** difference between the solid axle and independent suspensions.

(4 marks)

- (b) Suspension assembly is separated into dependent and independent suspension. Explain the purpose of independent suspension in the vehicle suspension system. Illustrate various forces acting on independent suspension respectively.

(4 marks)

- (c) The vehicle dynamics are influenced by longitudinal tire forces, aerodynamic drag forces, rolling resistance forces and gravitational forces. Based on a simple vehicle model:

- (i) Draw forces and related dimensions acting on the simple vehicle model

(4 marks)

- (ii) Derive vertical forces acting on the front tire, F_{z1} and rear tire F_{z2}

(8 marks)

- (d) Suspension assembly is classified into three basic geometries which will affect driving outcomes. Demonstrate those suspension geometries by using an appropriate diagram.

(3 marks)

-END OF QUESTIONS -