Universiti Tun Hussein Onn Malaysia

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER II
## SESSION 2022/2023

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| COURSE NAME | : | VEHICLE DYNAMIC |
| COURSE CODE | : | BNG 32003 |
| PROGRAMME CODE | : | BNG |
| EXAMINATION DATE | : | JULY/ AUGUST 2023 |
| DURATION | : | 3 HOURS |

INSTRUCTIONS

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 ANSWER SCHEME PAPER CONSISTS OF **FIVE (5)** PAGES

**Q1** (a) Vehicle dynamics is a part of automotive development method that focuses on studying the behavior and performance of a vehicle while it is in motion. It involves analyzing various characteristics to ensure that the vehicle meets the desired performance standards

(i) Explain **THREE (3)** classification of fundamental approach to vehicle dynamics.

(6 marks)

(ii) Analyze **FOUR (4)** factors which affecting vehicle dynamics using fundamental approach.

(8 marks)

(b) The behavior of the brake tire plays an important role in controlling the horizontal motion of the vehicle. In vehicle dynamics studies, a good representation of brake and tire behavior is a necessity.

(i) Draw and derive an equation on how forces act on the shoes of drum brake by assuming two surfaces of brake lining contacted with the drum housing.

(8 marks)

(ii) List **THREE (3)** possible causes of the accident which relate to the antilock brake system.

(3 marks)

**Q2** (a) Bernoulli's principle explains that vehicle shape can achieve lift because of the shape of its body. Based on Bernoulli's principle, define downforce and drag force by using an aid of diagram.

(4 marks)

(b) There are **THREE (3)** specific types of aerodynamic drag components that can affect a vehicle's dynamics road load. Explain the different types of aerodynamic drag elements that can have an impact on a vehicle's dynamics and how careful engineering and design can help to reduce these elements of drag.

(6 marks)

(c) The drag coefficient of a car at the design conditions of 1 atm, 25°C (assuming air density at $\rho = 1.164$ kg/m$^3$) and 90 km/h is to be determined experimentally in a large wind tunnel in a full-scale test. The height and width of the car are 1.40 m and 1.65 m, respectively. If the horizontal force acting on the car is measured to be 300 N, determine the total drag coefficient of this car.

(4 marks)

(d) A car with a frontal area of 2.0 $m^2$ is traveling at a speed of 100 km/h in air with a density of 1.2 $kg/m^3$. The lift coefficient of the car is 0.2, and the distance between its center of gravity and aerodynamic center is 1.5 m. Calculate the aerodynamic rolling moment acting on the car.

(4 marks)

(e) Rolling resistance is the combination of forces that work against the forward motion of your vehicle. Derive rolling resistance equation during rotating condition.

(7 marks)

**Q3** (a) One of the very known and useful model to study the comfort and stability of the vehicle is the quarter car model suspension system. With appropriate diagram, derive quarter car suspension system model which represents sprung acceleration, $\ddot{x}_1$ and unsprung acceleration, $\ddot{x}_2$.

(6 marks)

(b) Half-car, and Full-car models are commonly used in vehicle dynamics analysis and are used to study the dynamic behavior of the vehicle's suspension system. Provide a comparison table including the number of wheels, degree of freedom, and any advantages and disadvantages of each model

(8 marks)

(c) A car is driving along a circular track of radius 100 meters at a constant speed of 72 km/h. However, the track is banked at an angle of 10 degrees. If the coefficient of friction between the car's tires and the track is neglected, Calculate the maximum safe speed that the car can maintain without slipping off the track. (Assume the car's weight is 1500 kg.)

(5 marks)

(d) Heavy vehicles were found to be easily roll-over during an event of high-speed cornering. High roll moment distribution is one of the causes. Explain **FOUR (4)** parameters or methods which can reduce vehicle roll moment.

(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)

**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) Describe the function of the dependent suspension in the vehicle.

(2 marks)

(ii) With the aid of a diagram, distinguish the differences between **TWO (2)** types of independent suspensions.

(7 marks)

(b) Suspension assembly is separated into dependent and independent suspension. Describe the purpose of independent suspension in the vehicle suspension system and 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 front tire, $F_{z1}$ and rear tire $F_{z2}$

(8 marks)

**-END OF QUESTIONS-**

**FINAL EXAMINATION**

SEMESTER / SESSION : SEM II 2022/2023
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COURSE CODE : BNG32003

**Formulae**

$$\eta_b = \frac{D_{act}}{\mu_p}$$

$$\mu_p = \frac{F_{f@r}}{W_{f@r}}$$

$$D_A = \frac{1}{2}\rho v^2 C_D A$$

$$L_A = \frac{1}{2}\rho v^2 C_L A$$

$$S_A = \frac{1}{2}\rho v^2 C_s A$$

$$PM = \frac{1}{2}\rho v^2 C_{PM} AL$$

$$YM = \frac{1}{2}\rho v^2 C_{YM} AL$$

$$RM = \frac{1}{2}\rho v^2 C_{RM} AL$$

$$R_x = R_{xf} + R_{xr} = f_r W$$

$$\delta = \frac{L}{R}$$