

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 5

LEFEL 5

EXAMINATION PERIOD
JULY 2019

CYFNOD ARHOLIADAU
GORFFENNAF 2019

MODULE CODE: M5X00402
Motorcycle Dynamics

TIME: 2 HOURS

ANSWER 3 OUT OF 4 QUESTIONS

Equipment or materials required – Calculator

Question 1

Shown below is the Triumph 765 Moto2 development bike;



It has a mass of 147Kg and wheelbase of 1,410mm.

The front un-sprung mass is 7.5Kg and the rear un-sprung mass is 12.5Kg.

The rear suspension has an average link ratio of 2.2 with the front suspension having a rake angle of 24.8° with a trail value of 104.3mm.

With a 75Kg rider the weight distribution is front biased at 62:38.

- a. Using your knowledge of suspension design and using reasonable assumptions, specify suitable front and rear spring rates for the suspension springs.
(10 marks)
- b. The damping for the motorcycle can be determined once the spring rates and masses are confirmed. Using simple assumptions for the damping ratio, show the approximate damping values you would expect for the compression and rebound damping of the front forks.
(5 marks)
- c. At high lean angles on the circuit, the operation of the suspension system becomes limited in its operation and this has consequences for the performance of the motorcycle. What design criteria are important in terms of ensuring performance at high lean angles and what parameters are used to characterise the bikes performance in this respect?

(5 marks)

Question 2

The variation in a motorcycles tyre thickness can be taken into account in regard to how much it would change the 'ideal lean angle' of a bike.

- a) Derive an equation for the 'ideal lean angle'
(4 marks)
- b) Show how the 'ideal lean angle' can modified to include the effect of the tyre width of the motorcycle?
(6 marks)

The wheel loads of a motorcycle are normally represented by N_f and N_r , representing the combination of static and dynamic loads acting on the motorcycle.

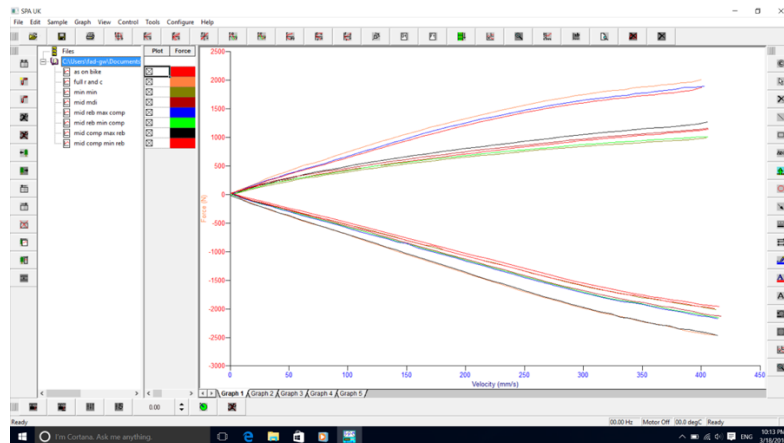
- c) From first principles, derive equations for both N_f and N_r .
(7 marks)
- d) How much do you expect the wheel loads of the motorcycle to change in a cornering situation if the motorcycle is able to hold a lean angle of 55 degrees?
(3 marks)

Question 3

The suspension of a motorcycle is the complex control of a mass on a spring in order to optimise the tyre contact with the road and to ensure rider comfort.

- a) Explain how these dampers, in the context of a motorcycle suspension, are tested and evaluated with reference to the diagram below.

(5 marks)



The front or rear suspension of a motorcycle can be approximated as a simple mass-spring-damper problem with a simple mass m attached to springs of stiffness k with viscous dampers with damping coefficients c .

- b) If a sprung mass of 75kg is supported by a spring of stiffness 13.5 Nmm^{-1} with a damping constant of 900 Ns m^{-1} , determine the general solution for the suspension system and state what damping regime the system is in?
- c) Find the position of the mass at any time t if it starts from the equilibrium position and is given a push start with an initial velocity of 1.4 ms^{-1}

(5 marks)

(5 marks)

In a more complex sense, the motorcycle suspension can be represented as a multiple degree of freedom 'half car model'.

- d) Derive a set of equations that can be used to solve the case of a simple motorcycle suspension in pitch and bounce.

(5 marks)

The general solutions to 2nd order differential equations are given by:

$$y = Ae^{m_1x} + Be^{m_2x}$$

$$y = (A + Bx)e^{mx}$$

and

$$y = e^{\alpha x} [A.\cos(\beta x) + B.\sin(\beta x)]$$

Question 4

Explain in detail the process by which the rider gets from steady state straight-line motion, to steady state cornering.

- a) For a motorcycle speed of 10 ms^{-1} (4 marks)
- b) For a motorcycle speed of 50 ms^{-1} (4 marks)

Consider a motorcycle negotiating a 25m radius corner at 55 km h^{-1} .

The properties of the motorcycle are:

Mass, $m = 285 \text{ kg}$ (including rider)

Height of centre of gravity, $h = 0.65 \text{ m}$

Wheel radius, $R_f = R_r = 0.3 \text{ m}$

Spin inertia of front and rear wheels, $I_{w_f} = I_{w_r} = 0.44 \text{ kgm}^2$

- c) Calculate the gyroscopic moment generated by the motion of both wheels. (4 marks)

Due to gyroscopic reactions, the case described above is not in equilibrium. There are two ways in which the rider will be able to achieve equilibrium.

The first method is to displace the mass centre toward the centre of the turn.

- d) Calculate by how much the mass centre must move 'd' to achieve equilibrium? (5 marks)

The second method is to increase the roll angle ($\Delta\phi$).

- e) Determine the increase in roll angle needed to achieve equilibrium? (3 marks)