

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 5

LEFEL 5

EXAMINATION PERIOD
MAY 2017

CYFNOD ARHOLIADAU
MAI 2016

MODULE CODE: M5X00402
Motorcycle Dynamics

TIME: 2 HOURS

ANSWER 3 OUT OF 4 QUESTIONS

Equipment or materials required – Calculator

Question 1

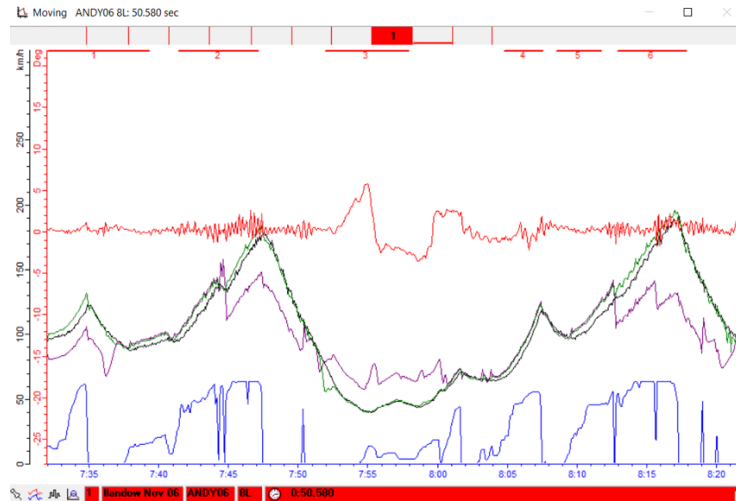
A motorcycle with suspension can be represented as several simple masses m attached to springs of stiffness k with viscous dampers with damping coefficients c . The displacement, x , representing the front and rear suspension displacements allows us to use the equation $ma + cv + kx = 0$ to represent the dynamics of the masses making up the system.

- a) Write the above equation as a second order differential equation, explaining the terms used. (2 marks)
- b) Describe what you understand by the term 'Ride Frequency' (3 marks)
- c) What do you understand by the phrase 'Critical Damping'? (3 marks)
- d) Describe how the 'Damping Ratio' can be used to define damping characteristics. (2 marks)
- e) If a sprung mass of 100kg is supported by a spring of stiffness $6,400 \text{ Nm}^{-1}$ with a damping constant of 2000 Ns m^{-1} , determine the general solution for the system and state what damping regime the system is in? (5 marks)
- f) Find the position of the mass at any time t if it starts from the equilibrium position and is given a push to start it with an initial velocity of 0.6 ms^{-1} (5 marks)

Question 2

The dynamics of the motorcycle are affected primarily by the gyroscopic influence of the rotating components of the motorcycle.

- a) Explain in detail how applying a torque to a rotating gyroscope affects its orientation. (4 marks)
- b) With reference to the data trace on the diagram below, explain why the steering trace (red) is only showing significant steer angle over a small proportion of the lap. (4 marks)



For a simple gyroscope with the following properties:

Weight = 88.2g

Speed = 8,500 rpm

Disk Radius = 26.5 mm

Axle length (Origin to disk) = 40 mm

- c) Calculate the moment of inertia of the disk (assume simple geometry)? (2 marks)
- d) Label the 3 axes of rotation? (you may sketch your answer) (1 mark)
- e) Explain what is meant by gyroscopic precession and why it happens? (3 marks)
- f) If the gyroscope is precessing in an anticlockwise direction as viewed from above, show which direction the gyroscope disk is rotating? (you may use a sketch to help show your answer) (2 mark)
- g) From the information you have been given, calculate the time taken for the gyroscope to make one revolution (precession) about its central pivot. (4 marks)

Question 3

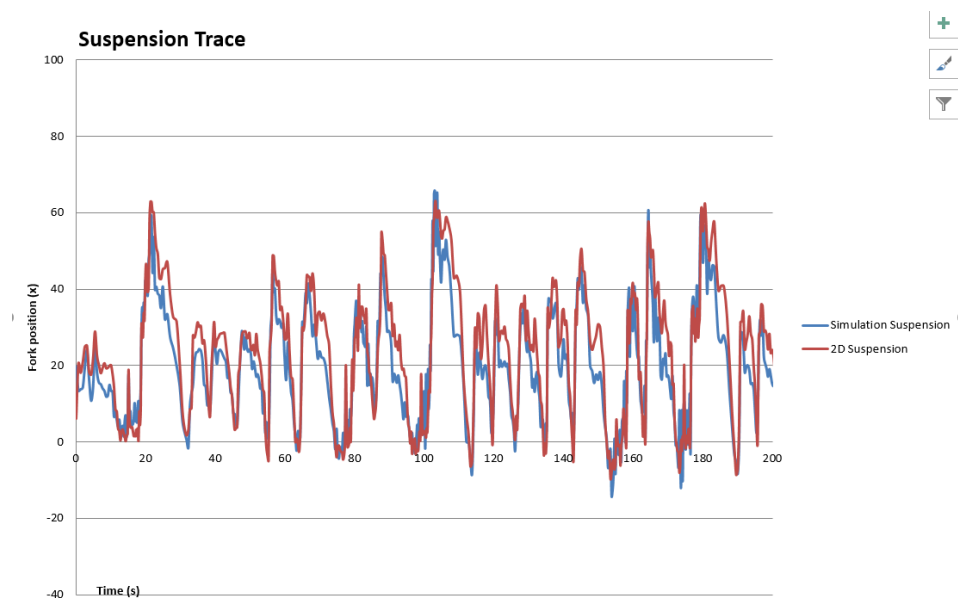
The Honda CRF1000L Africa Twin has the following specifications:

Total mass – 232 kg
CofG bias – 50% front
Front un-sprung mass – 8 kg
Rear un-sprung mass – 11.2 kg
Rear link ratio – 2.1 (average)
Rake angle – 27.5 degrees

- a) Using your knowledge of suspension design, determine the required spring rates for the shocks and forks for a 75 kg rider. (12 marks)

Shown below is a comparison between ‘simulated suspension trace, using wheel velocity as a start point’ and ‘measured suspension data’ for a MotoGP bike.

- b) Explain how the simulated trace is generated. (4 marks)
- c) What do you need to do to the trace to make it more useful to a suspension technician and how would you be limited in achieving this for a simulated trace? (4 marks)



Question 4

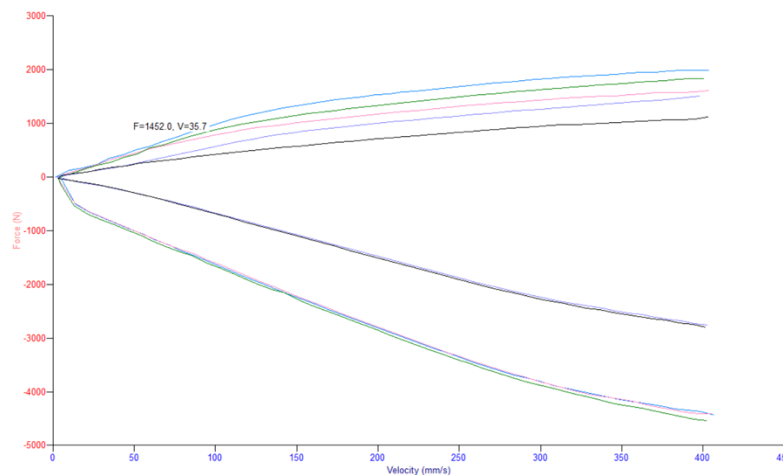
Recently, external ‘winglets’ have been introduced and subsequently banned in MotoGP. This has resulted in a great deal of aerodynamic development to create ‘internal aerodynamics’ for the 2017 MotoGP season.

- a) What is it you believe that the ‘winglets’ are designed to do and what evidence is there to support your theory. (2 marks)
- b) What would be the effects of ‘downforce’ on the dynamics of a MotoGP bike? (2 marks)

The handling characteristics of the modern MotoGP bike have changes greatly in the last 5 years to the extent that they are now very different in characteristic to the support classes and WSB.

- c) How has the geometry and dynamics of the MotoGP bike changed and how is it effecting the riding style and rider requirements? (4 marks)

Shown on the diagram below is a damper dynamometer trace for Kayaba rear shock from a Yamaha TZ250 with a link ratio of 2.7. The only settings used are combinations of max and min compression and rebound with no intermediate settings.



- d) Describe the main features you can determine about this particular shock absorber and its damping characteristics. (2 marks)
- e) From the graph, estimate the values of the maximum and minimum rebound damping (3 marks)
- f) What values would these translate to ‘at the wheel’? (3 marks)
- g) If the vertical ‘wheel rate’ is $18 \text{ N}\cdot\text{mm}^{-1}$ and the sprung mass at the rear is 112kg, determine the damping ratio. (4 marks)