

Question 1

The methods used to steer a motorcycle are both complex and non-intuitive. Using your understanding of motorcycle dynamics, describe the process by which you steer a motorcycle in the following conditions.

- a) Braking from high speed before entering a fast 'right-hander' such as 'Honda Curve' on the back straight of Pembrey Circuit. (4 Marks)
- b) Performing a 'turn in the road/U-turn' maneuver, such as you would do during your practical bike riding test. (4 Marks)
- c) With reference to the photograph below, describe in detail the effects that 'steering' the motorcycle will have on the motorcycle while the wheel remains in the air.



(4 Marks)

Consider the case of a rider negotiating 'Brooklands Hairpin' at Pembrey circuit on a Honda VFR400 motorcycle:

Corner radius, $R_c = 25$

Forward speed, $V = 50 \text{ km h}^{-1}$

The properties of the motorcycle are:

Mass, $m = 225 \text{ kg}$ (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, $I_{wf} = I_{wr} = 0.44 \text{ kgm}^2$

- d) Calculate the yaw velocity of the motorcycle. (2 marks)
- e) Calculate the angular velocity of each wheel. (2 marks)
- f) Determine the *ideal* roll angle of the motorcycle through this turn. (2 marks)
- g) Calculate the gyroscopic moment generated by the motion of both wheels. (2 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.

(6 marks)

For a simple gyroscope arranged as shown below:



Which has the following properties:

Weight = 88.2g

Speed = 8,500 rpm

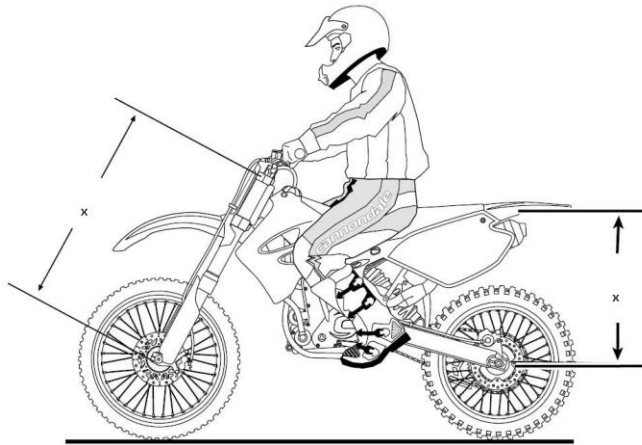
Disk Radius = 26.5 mm

Axle length (Origin to disk) = 40 mm

- b) Calculate the moment of inertia of the disk (assume simple geometry)? (2 marks)
- c) Label the 3 axes of rotation? (you may sketch your answer) (1 mark)
- d) Explain what is meant by gyroscopic precession and why it happens? (3 marks)
- e) 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)
- f) From the information you have been given, calculate the time taken for the gyroscope to make one revolution (precession) about its central pivot.

(6 marks)

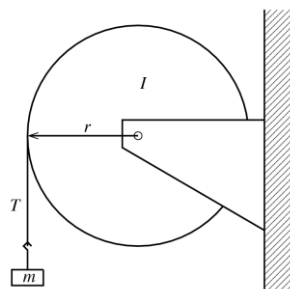
Question 3



A motorcycle with suspension can be represented as a number of 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.

- Write the above equation as a second order differential equation, explaining the terms used. (4 marks)
- Describe what you understand by the term 'Ride Frequency' (3 marks)
- What do you understand by the phrase 'Critical Damping'? (3 marks)
- Describe how the 'Damping Ratio' can be used to define damping characteristics. (2 marks)

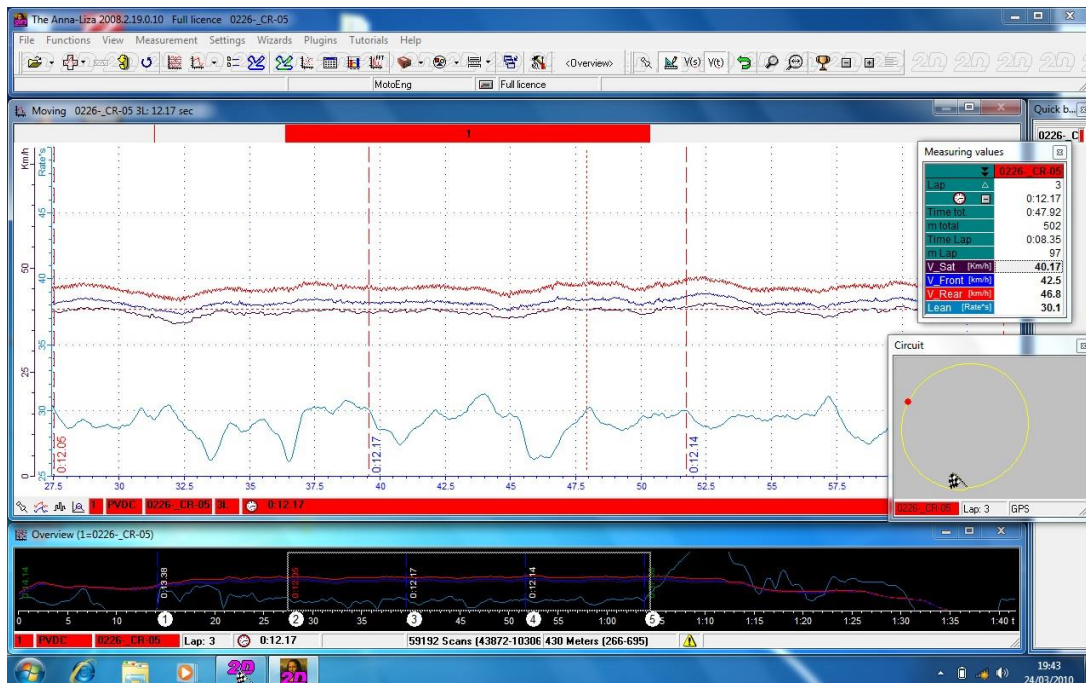
There are a number of experimental methods for determining the moment of inertia of a motorcycle wheel. In the case of the method shown in the diagram below:



- Derive an equation that can be used to calculate the moment of inertia of the wheel using just a meter ruler and a stopwatch. (8 marks)

Question 4

- Derive a set of equations that can be used to determine the wheel loads of a motorcycle in both static and dynamic situations.
(5 marks)
- Considering that wheel velocities are an integral part of any modern control system, what precautions have to be made when utilizing the raw data from these sensors?
(5 marks)
- Go on to explain what sensors might be required and how they would be implemented in modern control system.
(5 marks)



- For the motorcycle show in the above data trace, calculate the ideal lean angle and the 'real' lean angle assuming the test track diameter to be 45m and realistic values for the required motorcycle geometry and compare your solution to the data on the trace and discuss your results.
(5 marks)