

PRIFYSGOL CYMRU : UNIVERSITY OF WALES

**DEGREE EXAMINATIONS 2011
ARHOLIADAU GRADD 2011**

**Swansea Metropolitan University
Prifysgol Fetropolitan Abertawe**

Faculty of Applied Design and Engineering

NAME OF COURSE/PROGRAMME: *BEng Motorcycle Engineering*

YEAR or LEVEL (state which): *Year III*

NAME OF MODULE/UNIT: *Advanced Motorcycle Dynamics*

NAME OF EXAM PAPER:
(if different to module name)

DATE OF EXAMINATION:

EXAMINATION TIMES:

Start Time:

Finish Time:

Time Allowed:

INSTRUCTIONS TO CANDIDATES:

Answer 3 from 4 Questions

FACULTY REF:

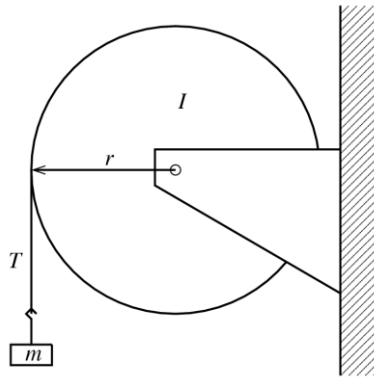
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Question 1.

- a. Explain what you understand by the term ‘Moment of Inertia’

(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:



- b. Using Newtonian methods, derive an equation that can be used to calculate the moment of inertia of the wheel.

(8 marks)

- c. Using the principles of conservation of momentum, show that the same equation can be derived.

(6 marks)

- d. If you were to perform a different experiment whereby you roll the wheel down a slope, show that the same equation can be used.

(4 marks)

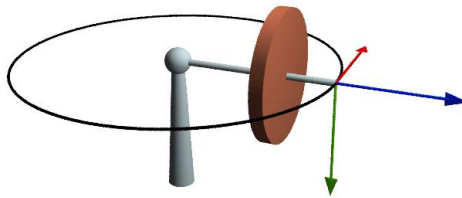
Question 2.

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:



The gyroscope has the following properties:

Weight = 111.2g

Speed = 10,000 rpm

Disk Radius = 26.5 mm

Axle length (Origin to disk) = 40 mm

- b. Calculate the moment of inertia of the disk?

(2 marks)

- c. Label the 3 axis shown on the diagram? (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, 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.

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

Corner radius, $R_c = 25 \text{ m}$

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, $I_{w_f} = I_{w_r} = 0.44 \text{ kgm}^2$

- a. Calculate the yaw velocity of the motorcycle. (2 marks)
- b. Calculate the angular velocity of each wheel. (2 marks)
- c. Determine the *ideal* roll angle of the motorcycle through this turn. (3 marks)
- d. Calculate the gyroscopic moment generated by the motion of both wheels. (3 marks)

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 increase the roll angle ($\Delta\phi$).

- e. Determine the increase in roll angle needed to achieve equilibrium? (4 marks)

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

- f. Calculate by how much the mass centre must move ' d ' in order to achieve equilibrium? (3 marks)
- g. What would be the effect on the effective roll angle if the motorcycle used tyres of a larger cross sectional area? (2 marks)
- h. What effect does the centre of gravity height have on the effective roll angle? (1 mark)

Question 4.

Consider a motorcycle about to negotiate a right turn...

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} (3 marks)
- b. For a motorcycle speed of 50 ms^{-1} (3 marks)

Consider a motorcycle with the following properties, at high speed through 'Honda Curve' (a fast right turn) at Pembrey Circuit. While exiting the corner the motorcycle enters a 'highside' situation throwing the rider off the left hand side of the vehicle.

Moment of inertia, $I\omega_f = I\omega_r = 0.55 \text{ kgm}^2$

Wheel Radius, $r_f = r_r = 0.3 \text{ m}$

Roll velocity, $\dot{\delta} = 1.8 \text{ rad s}^{-1}$

Velocity of the motorcycle, $v = 40 \text{ ms}^{-1}$

Rake angle, $\varepsilon = 22.5^\circ$

Normal trail, $a_n = 0.08 \text{ m}$

Handlebar width = 400mm

- c. Calculate the gyroscopic moment M_g that acts on the front frame around an axis lying in the plane of the motorcycle perpendicular to the longitudinal roll axis. (3 marks)
- d. Calculate the gyroscopic moment around the steering axis of the motorcycle due to its roll motion from right to left. What force at the handlebars would this accident result in? (3 marks)

Before departing the motorcycle, if you were able to turn the handlebars from right to left generating a gyroscopic moment around an axis perpendicular to both the steering head axis and the rotational axis of the front wheel.

- e. What effect does this gyroscopic moment have on the motorcycle? (3 marks)
- f. To counteract the roll rate due to the accident, what steer rate must be applied to the handlebars about the steer axis of the motorcycle? (5 marks)