



EXAMINATIONS 2012/2013 Semester 2

ARHOLIADAU 2012/2013

FACULTY OF: APPLIED DESIGN & ENGINEERING

NAME OF COURSE/PROGRAMME:
BEng Motorcycle Engineering

YEAR OR LEVEL: **Level 6**

NAME OF MODULE/UNIT/EXAM PAPER:
Advanced Motorcycle Dynamics

MODULE NO: M3X8817

DATE OF EXAMINATION:

EXAMINATION TIMES:

START TIME: 1.30 pm

FINISH TIME: 3.30 pm

TIME ALLOWED: 2 hours

INSTRUCTIONS TO CANDIDATES:

Answer any 3, from the 4 questions

Question 1

The weight distribution of a car can be determined by weighing the vehicle on a set of 'corner weight' scales. The four individual measurements can be used to determine four separate variables namely the total weight, the front/rear bias, the left/right bias and the wedge. These 4 equations can be solved simultaneously for the balance of the system.

The Formula One Sidecar can be analysed in a similar fashion. The 'Superside' outfit shown below has a 2m front/rear wheelbase and the chair wheel is 700mm forward of the rear axle.



- Derive a set of equations that represent the balance of the vehicle.
(5 marks)
- Show that for a vehicle of this type a 3x3 matrix can represent the vehicle setup.
(5 marks)
- Assuming that the vehicle weighs 185kg and requires a 50/50 front/rear balance and a 70/30 bike/chair bias, determine the required corner weights of the vehicle.
(7 marks)
- How does the gyroscopic effect of the front wheel affect the outfit's ability to steer?
(3 marks)

Question 2

The motorcycle has two main types of vibrational modes:

The in-plane and out-of-plane modes of vibration for a motorcycle are affected by different parameters.

- a. Explain what influences the in-plane vibrational modes and what effect this has on the motorcycle and the rider.

(3 marks)

- b. Explain what parameters influence the out-of-plane modes, and what mathematically determines the natural frequency of the oscillating modes.

(5 marks)



Experimentally, the motorcycle can exhibit a number of different oscillatory and non- oscillatory modes. Define the following terms and describe how they manifest themselves in motorcycle dynamics and how they are modeled mathematically.

- c. Capsize
- d. Wobble
- e. Weave

(12 marks)

Question 3

Consider a wheel climbing a step.



- a. If the radius of the wheel is R and the height of the step is h , find an expression for the vertical distance climbed, 's' such that

$$s = \sqrt{h(2R - h)}$$

(4 marks)

- b. As the wheel climbs the step a vertical distance 'y' and by equating the rate of climb to the rate of horizontal travel, show that:

$$\frac{dy}{dt} = V \sqrt{\frac{(h - y)(2R - h + y)}{(R - (h - y))^2}}$$

where V is the vehicle velocity.

(8 marks)

- c. The equation of motion for a mass-spring-damper system is given by the equation:

$$\ddot{x} + 2\zeta\omega\dot{x} + \omega^2x = 0$$

For $\zeta < 1$ and the initial conditions, when $t = 0$, $x = 0$ and $\dot{x} = 1$

Where $\beta = \sqrt{1 - \zeta^2}$, show that $x = \frac{1}{\beta\omega} e^{-\zeta\omega t} \sin(\beta\omega t)$

(8 marks)

Question 4

The motorcycle in its plane of symmetry can be represented as three rigid bodies whose vibrating motion is described by four independent coordinates:

- The vertical displacement of the sprung mass centre.
- The pitching rotation of the sprung mass.
- The vertical displacements of the *two* unsprung masses.



Draw a schematic representation of the system.

(6 marks)

Show that the equations of free, undamped motion can be described as:

$$\begin{bmatrix} m & 0 & 0 & 0 \\ 0 & I_y & 0 & 0 \\ 0 & 0 & m_f & 0 \\ 0 & 0 & 0 & m_r \end{bmatrix} \begin{pmatrix} \ddot{z} \\ \ddot{\theta} \\ \ddot{z}_f \\ \ddot{z}_r \end{pmatrix} + \begin{bmatrix} k_f + k_r & (p-b)k_f - bk_f & -k_f & -k_r \\ (p-b)k_f - bk_r & (p-b)^2 k_f + b^2 k_r & -(p-b)k_f & bk_r \\ -k_f & -(p-b)k_f & k_f + k_{t_f} & 0 \\ -k_r & bk_r & 0 & k_r + k_{t_r} \end{bmatrix} \begin{pmatrix} z \\ \theta \\ z_f \\ z_r \end{pmatrix} = 0$$

(14 marks)