SWANSEA METROPOLITAN UNIVERSITY
PRIFYSGOL FETROPOLITAN ABERTAWE

EXAMINATIONS 2012/2013Semester 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

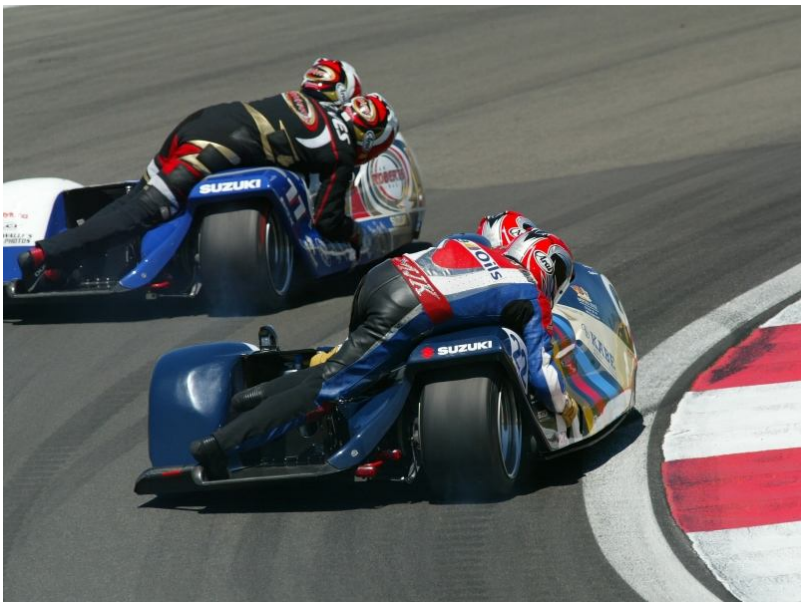
INSTRUCTIONS TO CANDIDATES:

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.



a. Derive a set of equations that represent the balance of the vehicle.
(5 marks)

b. Show that for a vehicle of this type a 3x3 matrix can represent the vehicle setup.
(5 marks)

c. 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)

d. 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:

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

where *V* is the vehicle velocity. (8 marks)

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

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

For ζ < 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)