[ESS37]

UNIVERSITY OF BOLTON

NATIONAL CENTRE FOR MOTORSPORT ENGINEERING

BEng (HONS) AUTOMOTIVE PERFORMANCE ENGINEERING (MOTORSPORT)

SEMESTER TWO EXAMINATION 2018/2019

ADVANCED VEHICLE SYSTEMS

MODULE NUMBER MSP6011

Date: Monday 20th May 2019 **Time: 14:00 – 16:00**

INSTRUCTIONS TO CANDIDATES

This paper has FOUR questions

Attempt ALL questions

The marks for each question are shown in brackets

Electronic calculators may be used provided that data and program storage memory is cleared prior to the examination

Mobile telephones or cellular telephones may-not be used as calculators

Formula sheet attached

Question 1

A quarter car model of a vehicle suspension system is shown in figure Q1.

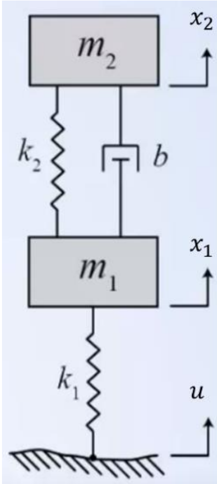


Figure Q1

(a) Develop the differential equations describing the motion of the system.
(20 marks)

(b) Explain why, for road cars, it is possible to simplify the quarter car model as a single mass-spring-damper system. **(5 marks)**

Total 25 marks

Question 2

A DC motor is represented as a first order system with a time constant of 1.5s.

When the input voltage is subject to a step increase from 0v to 5v, the speed of the motor increases from 0rpm to 12,000rpm.

a) Derive a transfer function that represents the time response of the motor.
(5 marks)

b) Calculate the time taken for the motor to reach 90% of its final value of 12,000rpm **(7.5 marks)**

c) Calculate the speed of the motor after 2s. **(7.5 marks)**

d) If the motor speed is measured and converted to a 10-bit digital signal, what is the value of the digital signal for the speed calculated in part c.
(5 marks)

Total 25 marks

PLEASE TURN THE PAGE….

Question 3

A simplified quarter car suspension model has been developed for a GT spec racecar. The model consists of a mass representing the mass of one corner of the car, and a spring and damper in parallel, which represent the effective spring rate and damping rate of the suspension.

The model is subjected to a unit step input and the output time response is shown in figure Q3 (page 5).

a) Using the data in figure Q3, calculate the damping ratio of the suspension system and comment on this in the context of a racecar suspension system containing 4-way adjustable dampers. **(10 marks)**

b) Using the data in figure Q3, derive a transfer function that represents time response of the system. **(10 marks)**

c) If the sprung mass of the quarter car is 300kg, calculate the damping rate of the system. **(5 marks)**

Total 25 marks

PLEASE TURN THE PAGE….

Question 4

A racecar is equipped with a CAN-bus network to enable transmission of digital signals. The bus is a CAN 2.0B network with a bus speed is 1Mbit/s. The message layout is shown is figure Q4.

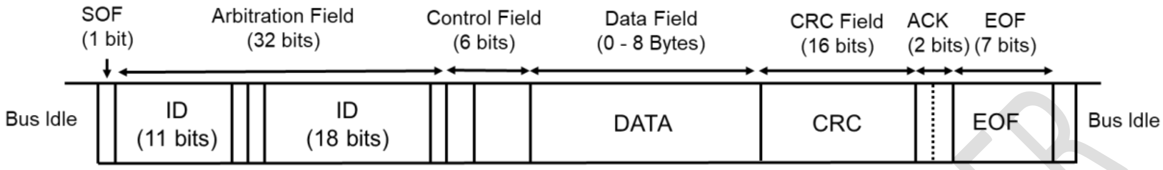


Figure Q4

One device is required to transmit three 32-bit messages at a rate of 500Hz. The non-data fields take up 64 bits of the message.

a) Calculate the worst case bus load due to the device, assuming maximum bit-stuffing takes place in the first 5 fields of the message (SOF, Arbitration, Control, Data and CRC) **(10 marks)**

b) Is it possible to reduce the bus load while still transmitting the three 32-bit messages at the same rate? How can this be achieved and what could the bus load be reduced to? **(10 marks)**

c) 3 message ID's are available for the device, 0x11A, 0x640, 0xB64. Which of these message ID's would you assign to the highest priority message and why? **(5 marks)**

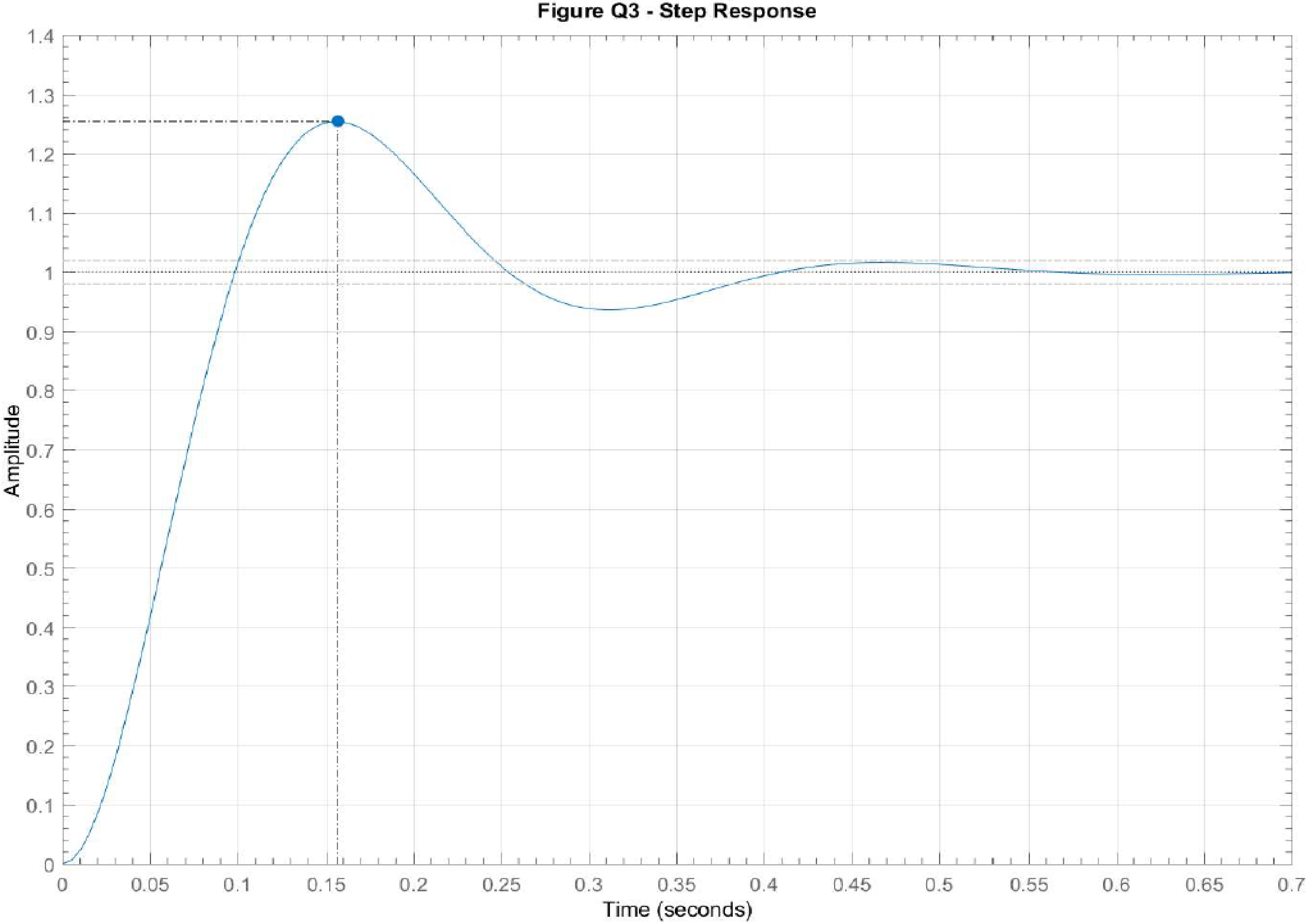
Total 25 marks

END OF QUESTIONS

Figure Q3 and formula sheets over the page….

PLEASE TURN THE PAGE….

National Centre for Motorsport Engineering
BEng (Hons) Automotive Performance Engineering (Motorsport)
Semester Two Examination 2018/2019
Advanced Vehicle Systems
Module No. MSP6011



Students Number: ___________________________________

FORMULA SHEET

1st Order Systems:

$$\tau\dot{y}(t) + y(t) = ku(t)$$

$$G(s) = \frac{Y(s)}{U(s)} = \frac{k}{\tau s + 1}$$

2nd Order Systems:

$$\ddot{y}(t) + 2\zeta\omega_n\dot{y}(t) + {\omega_n}^2 y(t) = {\omega_n}^2 u(t)$$

$$G(s) = \frac{Y(s)}{U(s)} = \frac{{\omega_n}^2}{s^2 + 2\zeta\omega_n s + {\omega_n}^2}$$

$$\omega_d = \omega_n\sqrt{1-\zeta^2}$$

$$t_s = \frac{4}{\tau} \approx \frac{4}{\sigma} \approx \frac{4}{\zeta\omega_n}$$

$$t_p = \frac{\pi}{\omega_d}$$

$$M_p = e^{\left(\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}\right)}$$

Vehicle suspension:

$$\omega_n = \sqrt{\frac{k}{m}}$$

$$b = 2\zeta\omega_n m$$

$$\zeta = \frac{b}{2\omega_n m}$$

END OF PAPER