

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 5

LEFEL 5

**EXAMINATION PERIOD
MAY 2019**

**CYFNOD ARHOLIADAU
MAI 2019**

MODULE CODE: M5X00404

POWERTRAIN AND CONTROL

TIME: 2 HOURS

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ANSWER 3 OUT OF 4 QUESTIONS

Equipment or materials required – Calculator

QUESTION ONE

You are required to analyse the valve dynamics of a camshaft/cam follower system for a Triumph Tiger 800 XC using the supplied table of data at the bottom of this page.

Assuming the total moving mass to be 0.08 kg and that the contact force between the camshaft and the cam follower becomes zero at full lift when float occurs.

Given that the spring stiffness of the valve springs in the standard engine is 22,000 N.m⁻¹ with an initial compression of 4 mm, determine the following:

- a) Using your understanding of the valve's dynamic motion, determine the valve acceleration (in m.s⁻²) at which float would be expected to occur. (4 marks)
- b) With reference to the table below, calculate both the valve velocity (mm/°) and the valve acceleration (mm/°/°) at the provided lifts. (3 marks)
- c) Sketch typical graphs of lift, velocity and acceleration and show what sign the acceleration would be at full lift. (3 marks)
- d) The uppermost end of the 'red-line' for the Triumph Tiger is shown at 12,000 RPM. By determining the valve acceleration at this rpm (in m.s⁻²), show that this RPM is safe in terms of potential valve float. (5 marks)
- e) Assuming that you are able to increase the 'rev limit' of the Triumph Tiger, determine the RPM that you would expect valve float to occur and the safe limit that you would assume reasonable in a performance application. (5 marks)

Cam Angle ATDC (°)	Valve Lift (mm)
106	7.988
107	7.994
108	7.998
109	8.000
110	8.000
111	7.998
112	7.994
113	7.998

QUESTION TWO

You are required to consider the intake design of a 5.0 litre Ford Mustang V8, naturally aspirated engine induction system. The intake system consists of a plenum and fixed intake system. The stock car produces 343kW @ 7000RPM and 569Nm of torque at 4,600RPM.

The performance camshaft is symmetrical and gives a valve duration of 270 degrees. Assume maximum opening point is 108 degrees after top dead centre. Assume the speed of sound at 20°C is 330 m.sec⁻¹, the density of air at 20°C is 1.2 kg.m⁻³ and assume 1 Bar = 10⁵ Pascals.

- a) Assuming the intake port length is 80mm, calculate the intake trumpet length to optimise the intake for peak torque output. Explain fully the physics of your calculations and explain which harmonic you are using.
(6 marks)
- b) Now calculate the intake length required to achieve best tuning at peak power. Explain which harmonic you are using and if you think these two lengths could be packaged as a variable intake system.
(4 marks)
- c) You are now required to carry out a harmonic analysis up to the 7th harmonic for both of the above lengths you chose to use. Which length do you believe provided the most useful harmonic spread for a fixed intake for a road based application?
(5 marks)
- d) Calculate the potential engine performance benefit if the air inlet could be moved from a position of 50°C air temperature to position of 20°C air temperature. Explain the physics of your reasoning.
(3 marks)
- e) Calculate the additional performance potential of a forward-facing plenum at top speed for the Mustang (top speed is 250 km.h⁻¹) compared to dynamometer testing of a stationary engine in still air at the same temperature.
(5 marks)

QUESTION THREE

The combustion process for internal combustion engines are usually defined using a function called the 'Wiebe' function.

- a) Write down the Wiebe function (2 marks)
- b) Sketch what the Wiebe function looks like and explain how it is used to represent the combustion process. (3 marks)
- c) If during combustion, the fuel releases an average of 863 J, calculate the increase in pressure in the cylinder if the volume changes from 48.2 cc to 35.2 cc and the initial pressure at the start of the change is 24.5 Bar? You may assume that the polytropic index is 1.35 and that the ratio of specific heats (γ) is 1.25 (5 marks)
- d) From first principles, show that:

$$PV^\gamma = \text{Constant}$$

(10 marks)

QUESTION FOUR

You are required to carry out calculations on a naturally aspirated 5.0L 'Coyote' V8 Ford Mustang engine with a cylinder displacement of 625cc and a compression ratio of 12:1.

Assume that the cycle is a constant volume Otto cycle with instantaneous burning and heat input at Top Dead Centre (TDC).

Assume that the intake stroke is complete at Bottom Dead Centre (BDC) and that the exhaust valve opens at BDC.

The engine is not quite adiabatic but has a polytropic index of 1.33 during compression and 1.28 during the expansion stroke.

Assuming that the air intake temperature is 20°C @ 1Bar, Calculate:

- a. The temperature of the air/fuel mix just before the start of combustion. (3 marks)
- b. The rise in temperature of the air/fuel mixture during combustion. (6 marks)
- c. The temperature of the exhaust gas. (2 marks)
- d. The peak pressure in the cylinder. (4 marks)
- e. The potential energy recoverable from the exhaust gas per cycle. (2 marks)
- f. Draw a P-V diagram for a real engine, labelling the 4 different parts of the typical four-stroke cycle and the important parameters of the cycle. (3 marks)

You may use the following information:

Density of air at 20°C = 1.2 kg m⁻³

Volumetric efficiency is 90%

Combustion efficiency is 90%

Calorific value of fuel = 44x10⁶ J kg⁻¹

Air/Fuel ratio = 13.2:1

Specific heat of air/fuel or exhaust gas at constant volume = 1007 J kg⁻¹ K⁻¹

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