



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 5

LEFEL 5

EXAMINATION PERIOD
MAY 2017

CYFNOD ARHOLIADAU
MAI 2017

MODULE CODE:M5X00404

POWERTRAIN AND CONTROL

TIME: 2 HOURS

ANSWER THREE QUESTIONS OUT OF FOUR

Note that in all your answers, marks will be awarded for detailed explanation of the calculation steps

QUESTION ONE

You are required to analyse the performance of a Moto-GP induction system. The intake system will include a plenum and active trumpets which can adjust their length by 40mm. The aim is to optimise the system for a race track with long straights requiring maximum power at 18000 RPM.

The valve duration is 310° and the camshaft is designed to be symmetrical in its lift profile. Maximum opening point has been set up at 114° after top dead centre (ATDC). The intake port length is 70mm. Assume the speed of sound at 20°C is 330 m / sec. Assume 1 BAR = 10^5 PASCALS.

a). Calculate the basic length of the intake trumpets to achieve the required tuning target. Which harmonic are you using? Explain the physics of your calculations.

(4 marks)

b). Assuming this length can now be actively increased by 40mm, calculate the engine RPM of best tuning for this longer length. Which harmonic are you using?

(4 marks)

c). Comment on whether this longer length tuning RPM seems suitable for this race application.

(2 marks)

d). Using the above two calculated lengths, carry out a harmonic analysis up to the 5th harmonic to show the lower RPM bands where positive tuning effects could also be seen. Show your results in a suitable table. Explain the physics of your calculations.

(3 marks)

e). You are now required to determine the extra performance possible by a forward facing air intake for the plenum, compared to engine testing on a stationary dynamometer with still air. Explaining the physics of your work, calculate the extra performance at bike speeds of 50 and 100m / sec respectively for this RAM effect. Assume density of air at 20°C is $1,2 \text{ kg / m}^3$.

(4 marks)

f). Discuss the merits of obtaining a cold air intake versus the merits of the RAM effect. Use numerical calculations to support your reasoning.

(3 marks)

QUESTION TWO

You are asked to investigate the tuning requirements of an exhaust system for a 4 cylinder 1200cc naturally aspirated drag racing engine. The engine is designed to have an operating power band between 8000 RPM and 12000 RPM.

The camshaft to achieve this is symmetrical and valve duration is 290 degrees. Maximum opening point is at 106 degrees before top dead centre (BTDC). The exhaust port length is 90mm. Assume that the speed of sound at 20°C is 330 m / sec and is proportional to the square root of the absolute temperature at higher temperatures.

a). Using a 4 into 1 exhaust manifold design, calculate the primary pipe length to achieve best pulse tuning at 12000 RPM. Explain the physics of your calculations and assume suitable exhaust gas temperatures at exhaust port and collector. Explain which harmonic you are using.

(4 marks)

b). The exhaust system is unsilenced. Assuming suitable temperatures, calculate the additional length from the collector to the tailpipe exit to achieve best pulse tuning at 8000 RPM. Fully explain the physics and your assumptions. Explain which harmonic you are using.

(3 marks)

c). Fully explaining your methodology, calculate the primary pipe internal diameter.

(3 marks)

d). If you wanted to improve the lower RPM torque of the engine, how would you adjust the primary pipe diameter? Fully explain your reasoning.

(2 marks)

e). You are required to improve the engine performance by adding a step in the primary pipe. Looking at the cam timing and making suitable assumptions for the temperature distribution down the primary pipe, calculate the best position of the step from the cylinder head. Fully explain the physics and the reasoning for your solution and the RPM you have optimised the step for.

(4 marks)

f). Explain how water injection into the exhaust could be used to keep the primary pipe length you have calculated to be pulse optimised from 8000 to 12000 RPM. Using your original assumed temperatures and pipe lengths, what mean temperature reduction would you need for these primary pipe lengths to be optimised at 8000 RPM? Explain your calculations.

(4 marks)

QUESTION THREE

You are asked to carry out a study of valve dynamics of a camshaft/cam follower system using the supplied table of valve lift (mm) against crank angle (degrees) data.

Crank Angle ATDC (°)	Valve Lift (mm)
106	9.976
107	9.988
108	9.996
109	10.000
110	10.000
111	9.996
112	9.988
113	9.976

Assume that the total moving mass is 0.08 kg

Firstly, you are asked to calculate the RPM speed at which the valve will float assuming the initial compression of the spring is 6mm and a spring stiffness of 40500 N/m

Carry out the answer in the following stages –

a). Calculate valve velocity in mm/°, valve acceleration in mm/°/°

(2 Marks)

b). Show typical graphs of lift, velocity and acceleration and show what sign the acceleration is at full lift.

(3 Marks)

c). When looking at valve dynamics, what is the equation of motion?

(2 Marks)

d). Calculate the acceleration at full lift in m/s²

(3 Marks)

e). Calculate the RPM float speed.

(4 Marks)

Secondly, you are now required to increase the float speed to 9500 RPM.

f). Calculate a new spring stiffness in N/m, using the existing moving mass, initial compression and cam profile.

(6 Marks)

QUESTION FOUR

You are asked to analyse the performance of a 3,8 litre twin turbocharged V6 engine. The table provided contains a selection of dynamometer readings at a number of load / RPM sites. You may assume that the stoichiometric air fuel ratio by mass is 14,7. Assume 1 BAR = 10^5 PASCAL.

RPM	BMEP BAR	FUEL FLOW KG / HOUR	LAMBDA
1000	8,1	6,5	0,87
3000	20,1	61,6	0,80
4000	19,7	76,5	0,82
6000	20,0	137,1	0,73
7000	19,7	163,1	0,73
8000	16,6	169,6	0,72

- a). Calculate the air mass flow rate in kg / hour for each map point. (2 marks)
- b). Calculate the trapped air and fuel mass for each map point. (2 marks)
- c). Calculate the volumetric efficiency at each map point. (2 marks)
- d). Derive the relationship between BMEP and torque from first principle definitions. (2 marks)
- e). Calculate the torque at each map point. (2 marks)
- f). Derive the relationship between BMEP and power from first principle definitions. (2 marks)
- g). Calculate the power at each map point. (2 marks)
- h). Calculate the brake specific fuel consumption BSFC in gms / kw.hr at each map point. (3 marks)
- i). Assuming the calorific value of the fuel is 44 mj / kg, calculate the overall engine efficiency at each map point. (3 marks)

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