

1.

Answers:

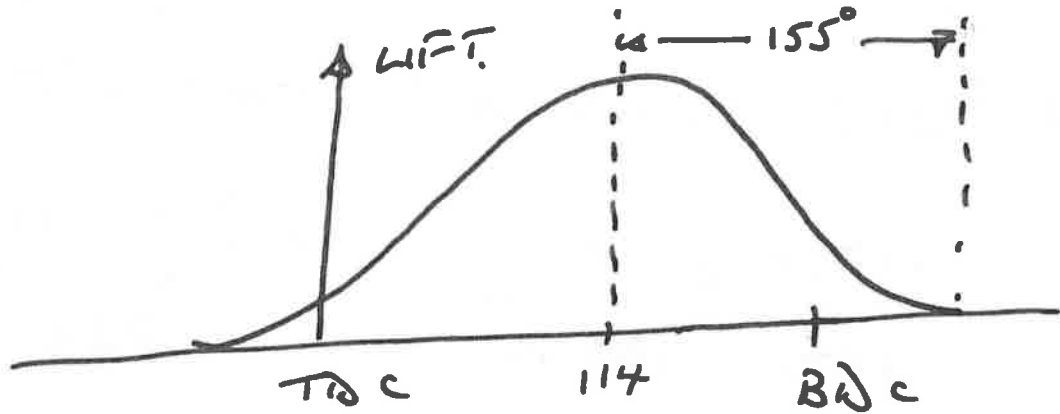
MAY/2017.

POWERTRAIN & CONTROL.

M5X00404

QUESTION 1.

(a)



MOP TO MIDWAY / BETWEEN
BDC & CHANGING

$$= \frac{66 + 155}{2}$$

$$= \underline{\underline{110.5^\circ}}$$



LET L = LENGTH OF INTAKE TRUMPET.

TIME FOR SUCTION PULSE

TO RETURN AS +VE

$$= \frac{2(L + 0.07)}{330} \times 1 \text{ sec}$$

$1/\alpha = 1.2, \dots$

2.

$$\begin{aligned} \text{TIME FOR CANT TO TURN } 110,5^\circ \\ = \frac{110,5}{360} \times \frac{60}{2PM} \text{ sec.} \end{aligned}$$

FOR BDT TUNING AT 18000 RPM

$$\frac{110,5}{360} \times \frac{60}{18000} = n \times \frac{2(L+0,07)}{330}$$

$$\begin{aligned} L + 0,07 &= \frac{330}{2n} \times \frac{110,5}{360} \times \frac{60}{18000} \\ &= \frac{0,17}{n} \end{aligned}$$

$$\begin{aligned} \text{FOR } n=1 \quad L &= 0,17 - 0,07 \\ &= 0,1 \text{ m} = \underline{\underline{100 \text{ mm}}} \end{aligned}$$

ADD EXPLANATION OF POWSE TUNING
PHYSICS.

3.

(b) using $n = 1$,

IF $L = 140 \text{ mm}$.

$$\frac{2n \cdot (0,14 + 0,07)}{330} = \frac{110,5}{360} \times \frac{60}{\text{RPM}}$$

$$\text{RPM} = \frac{330}{2 \cdot (0,21)} \times \frac{110,5 \times 60}{360}$$

$$\text{RPM} = \underline{\underline{14470}}$$

(c) 14470 RPM will be typically at bottom end of power band so good for engine.

(d) IF $L = 0,1$ or $0,14 \text{ m}$

THE RPMs will be as follows:

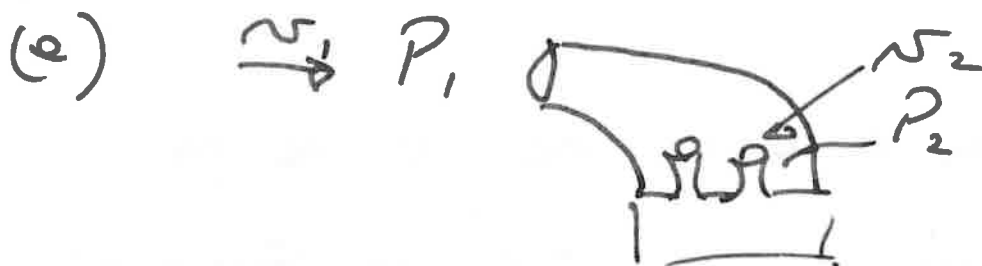
$$\underline{L = 0,1} \quad \text{RPM} = \frac{330}{n \cdot 2 \cdot (0,17)} \times \frac{110,5}{360} \times 60$$

4. $h = 0,14$

$$RPM = \frac{330}{n \cdot 2 \cdot 0,21} \times \frac{110,5}{360} \times 60$$

n	$h = 0,1$	$h = 0,14$
1	18000	14470
2	9000	7235
3	6000	4823
4	4500	3618
5	3600	2494

ADD EXPLANATION.



from Bernoulli

$$P_1 + \frac{1}{2} \rho v_1^2 = P_2 + \frac{1}{2} \rho v_2^2$$

5.

AT BASE PHENOM, $v_2 = 0$

$$\therefore P_1 + \frac{1}{2} \rho v_1^2 = P_2$$

$$\rho = 1,2 \text{ kg/m}^3$$

$$\text{AT } v_1 = 50 \text{ m/sec.}$$

$$P_1 = 1 \text{ BAR} = 10^5 \text{ N/m}^2$$

$$\therefore 10^5 + \frac{1}{2} \times 1,2 \times 50^2 = P_2$$

$$P_2 = \underline{\underline{1,015 \text{ BAR}}}$$

ie 1,5% GREATER AIR DENSITY
AND POTENTIAL PERFORMANCE
INCREASE

$$\text{AT } v_1 = 100 \text{ m/sec.}$$

$$10^5 + \frac{1}{2} \times 1,2 \times 100^2 = P_2$$

$$P_2 = \underline{\underline{1,06 \text{ BAR}}}$$

ie 6% GREATER AIR DENSITY AND
POTENTIAL PERFORMANCE INCREASE.

6.

using Ideal Gas Law

$$PV = nRT$$

$$\text{Density } \rho = \frac{m}{V}$$

$$\therefore P = \rho \cdot RT$$

$$\rho = \frac{P}{RT}$$

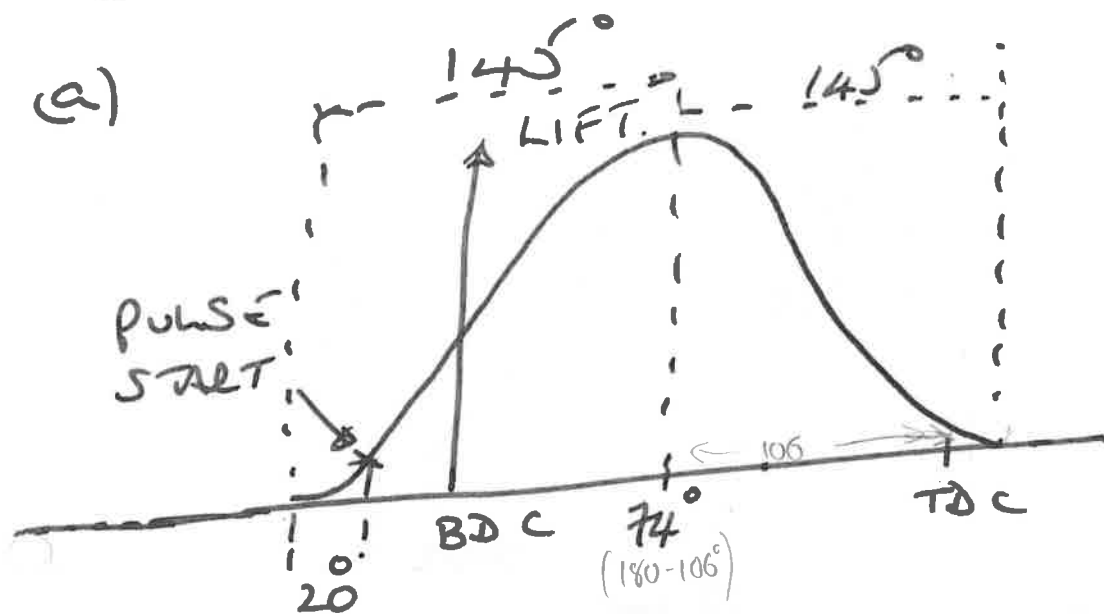
CHANGING Temp FROM $20^{\circ}\text{C} \rightarrow 50^{\circ}\text{C}$
CHANGING ABSOLUTE Temp FROM
 293 K TO 323 K .

$$\therefore \frac{\text{AIR Density AT } 20^{\circ}\text{C}}{\text{AIR Density AT } 50^{\circ}\text{C}} = \frac{323}{293}$$
$$= 1.1$$

REDUCING AIR INLET Temp FROM
 50°C TO 20°C CAN THEREFORE
INCREASE Density BY 10%.

7.

QUESTION 2

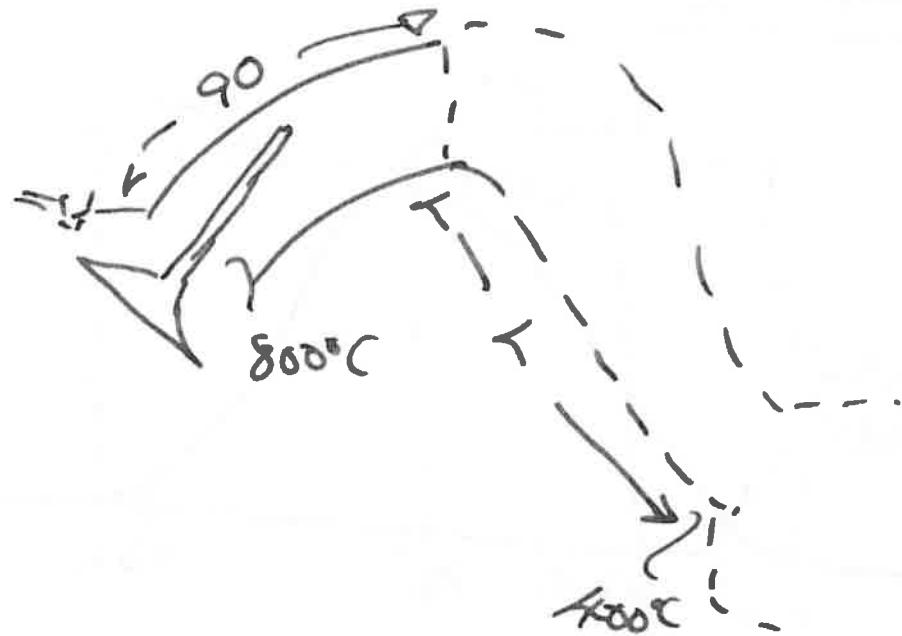


(a) MOD TO PULSE START = 125°
 MOD TO MIDWAY/
 BETWEEN TDC & CLOSING = $\frac{106 + 145}{2}$
 $= \underline{\underline{125.5^\circ}}$

PULSE START TO MIDWAY/
 BETWEEN TDC & CLOSING = $\underline{\underline{250.5^\circ}}$

TIME FOR CRANK TO
 TURN $250.5^\circ = \frac{250.5}{360} \times \frac{60 \text{ sec.}}{2 \text{ RPM}}$

8.



TOTAL DISTANCE FROM
EXHAUST VALVE TO COLLECTOR
 $= (L + 0.09) \text{ m.}$

TIME FOR +VE PULSE TO LEAVE
VALVE & RETURN AS A -VE
$$= \frac{n \cdot 2 \cdot (L + 0.09)}{v} \text{ secs}$$
$$n = 1, 2, 3$$

$$v = \frac{v_{\text{avg}}}{0.5}$$

ASSUME TEMPS ABOVE,
MEAN EXHAUST GAS TEMP $= 600^\circ\text{C}$

9. MEAN SPEED OF SOUND IN EXHAUST
IS GIVEN BY

$$v = 330 \times \sqrt{\frac{273 + 600}{293}}$$
$$= 563,5 \text{ m/sec.}$$

FOR 3RD TURN.

$$\frac{250,5}{360} \times \frac{60}{\text{RPM}} = \frac{n \times 2 \cdot (L + 0,09)}{563,5}$$

$$L + 0,09 = \frac{250,5}{360} \times \frac{60}{12000} \times \frac{563,5}{2n}$$

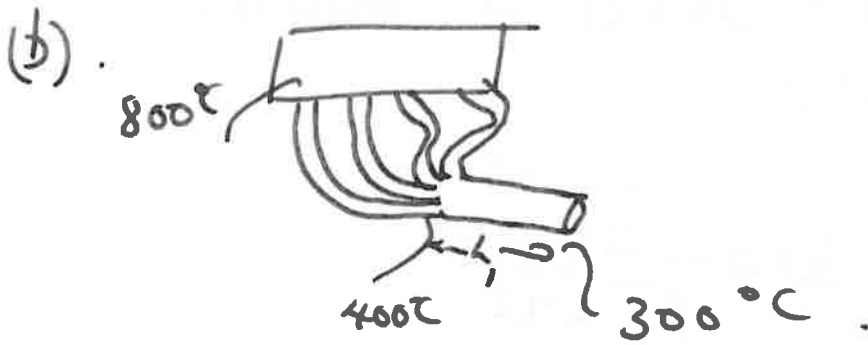
$$= \frac{0,98}{n}$$

$$\text{for } n = 1, L = 0,89 \text{ m.}$$

$$n = 2, L = 0,40 \text{ m}$$

TRY TO PARTIAL $n = 1$.

10.



MEAN TEMP. TO AIR PIPE = 550°C.

MEAN SPEED OF SOUND TO
AIR PIPE

$$= 330 \times \sqrt{\frac{550 + 273}{293}}$$

$$= \underline{\underline{552,2 \text{ m/s.}}}$$

BOT TURNING IS WHEN

$$\frac{250,5}{360} \times \frac{60}{8000} = \frac{n \times 2 \times (0,98 + L)}{552,2}$$

ASSUMING $n = 1$

$$\cancel{0,98} + L = \frac{552,2}{2} \times \frac{250,5}{360} \times \frac{60}{8000}$$

$$= 1,44 \text{ m}$$

$$0,46$$

$$\therefore L_1 = \underline{\underline{0,46 \text{ m.}}}$$

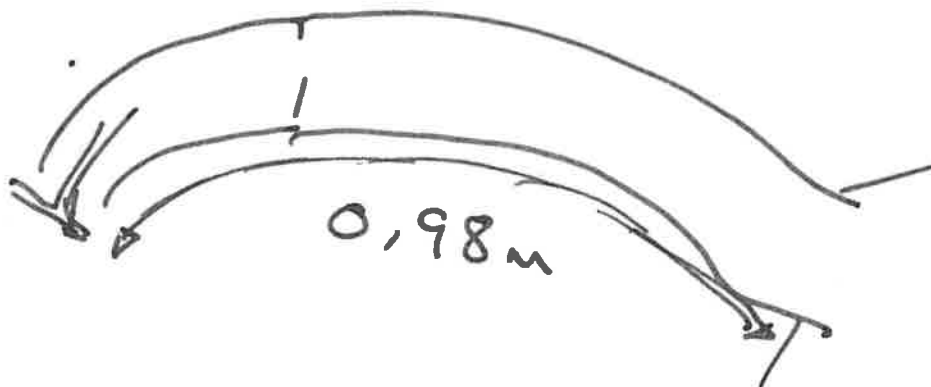
11.

(c) CYLINDER CAPACITY = 300 cu.

AIR COMES IN AT 20°C .

EXHAUST MAN TEMP
IN PRIMARY PIPE = 600°C

$$\begin{aligned}\therefore \text{TEMPERATURE RATIO} &= \frac{600 + 273}{20 + 273} \\ &= \frac{873}{293} \\ &= 2.98.\end{aligned}$$



CONVERT TO CMS

VOLUME IN PWT / PRIMARY

$$\sim \frac{98 \times \pi D^2}{4} \text{ cu} = 2.98 \times 300$$

$$\textcircled{1} = \underline{\underline{3.48 \text{ cms}}}$$

12.

(d) TO IMPROVE LOW SPEED TORQUE
REDUCE THE PIPE DIAMETER TO
INCREASE EXHAUST GAS VELOCITY
& SCRAMBLING EFFECT.

(e) CHOOSE THE STEP PORTION
TO BE OPTIMIZED AT 12000 RPM.

PART LENGTH = 90 mm

LET L_2 = DISTANCE OF STEP
FROM HERE.

EXHAUST VALVE OPENS 106°
BTDC.

HAVE FIRST NEGATIVE PULSE
FROM STEP RETURN $\sim 20^\circ$ BTDC
TO HELP BLOW-DOWN PROCESS.

ASSUME TEMP AT STEP = 700° .

$\therefore$ MEAN TEMP TO STEP = 750°

MEAN SPEED OF SOUND TO
STEP

$$= 330 \times \sqrt{\frac{1023}{293}}$$
$$= 615.6 \text{ m/sec.}$$

13.

For RWL TO RETURN, CURVE ANGLE
TOWARD FROM POWER START

$$= 106 - 20 - 20$$

$$= 66^\circ$$

$$\therefore \text{TIME FOR } 66^\circ = \frac{66}{360} \times \frac{60}{12000} \text{ sec}$$

$$= \frac{2(L_2 + 0,09)}{615,6}$$

$$L_2 + 0,09 = \frac{615,6}{2} \times \frac{66}{360} \times \frac{60}{12000}$$

$$= 0,28 \text{ m.}$$

$$\therefore L_2 = \underline{\underline{0,19 \text{ m.}}}$$

14.

(f) ORIGINAL TOTAL LENGTH FROM
VALVE TO COLLECTOR = 0,98m.

AT THE NEW TEMP OF 600°C
THIS WAS TUNED TO 12000 RPM.

ACCORDING TO

$$\frac{2 \times 0,98}{N} = \frac{250,5}{360} \times \frac{60}{\text{RPM}}$$

$$\text{IF RPM} = 8000$$

SOLVE FOR N

$$N = \frac{2 \times 0,98 \times \text{RPM} \times 360}{250,5 \times 60}$$

$$\text{GIVING } N = 376 \text{ m/sec.}$$

$$\therefore \frac{376}{330} = \sqrt{\frac{T}{293}}$$

$$T = 293 \times \left(\frac{376}{330} \right)^2 = 380 \text{ K.}$$
$$= \underline{\underline{107^\circ \text{C.}}}$$

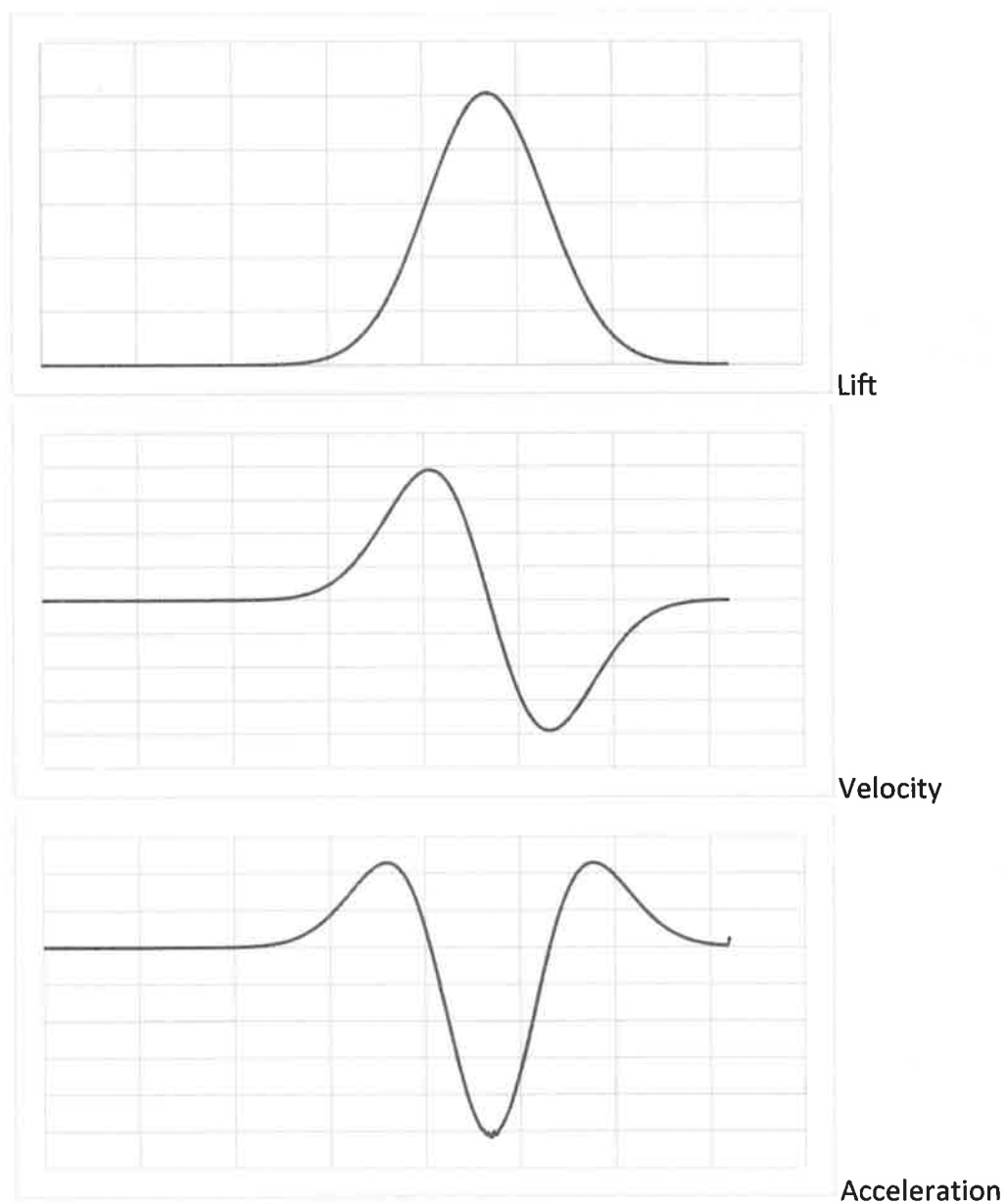
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Water would need to
drop HSA from 600°C to
 107°C to cover complete
RWA.

3a)

Crank Angle (Deg)	Valve Lift (mm)	mm/° (l2-l1)	mm/°/° (v2-v1)
106	9.976		
107	9.988	0.012	
108	9.996	0.008	-0.004
109	10	0.004	-0.004
110	10	0	-0.004
111	9.996	-0.004	-0.004
112	9.988	-0.008	-0.004
113	9.976	-0.012	-0.004

3b)



3c)

$$Fc - k(x + x_0) = m \times a$$

3d)

Transpose equation of motion for a, change lift and initial compression to meters.

$$a = \frac{Fc - k(x + x_0)}{m}$$

$$a = \frac{0 - 40500(0.010 + 0.006)}{0.08} = -8100 \text{ m/s}^2$$

3e)

Transpose the equation for mm/s^2 to RPM for RPM.

$$RPM = \frac{\sqrt{\frac{a \times 1000}{\text{mm}/\text{s}^2}}}{6}$$

$$RPM = \frac{\sqrt{\frac{-8100 \times 1000}{-0.004}}}{6} = 7500 \text{ RPM}$$

3f)

Take mm/s^2 , Multiply by $\frac{(6 \times RPM)^2}{1000}$ to get m/s^2 .

$$a = \frac{\text{mm}/\text{s}^2 \times (6 \times RPM)^2}{1000}$$

$$a = \frac{-0.004 \times (6 \times 9500)^2}{1000} = -12996 \text{ m/s}^2$$

Transpose equation of motion for k.

$$k = \frac{(-a \times m)}{(x + x_0)}$$

$$k = \frac{(-12996 \times 0.08)}{(10 + 6)} = 64.98 \text{ N/mm or } 64980 \text{ N/m}$$