

# Heat Engines Project



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## Engine Tables

Engine	Power [kW]	n [rpm]	S [mm]	D	Pcyl [kW/cyl]	Fuel type	Torque [Nm]	$\varepsilon$	i	V	Displacement volume
<b>VW Passat B8 1.4 TSI 150hp</b>	<b>110</b>	<b>5000- 6000</b>	<b>80</b>	<b>74. 5</b>	<b>27.5</b>	<b>Petrol</b>	<b>250</b>	<b>10.5</b>	<b>4</b>	<b>4</b>	<b>1395</b>
Audi Q3 8U 1.4 TFSI	110	5000- 6000	80	74. 5	27.5	Petrol	250	10.5	4	4	1395
Opel Astra 1.4 140hp	103	4900- 6000	82. 6	72. 5	25.75	Petrol	200	9.5	4	4	1364
Opel Insignia 1.5 140hp	103	5600	86. 6	74	25.75	Petrol	250	10.1	4	4	1490
Opel Meriva 1.4 Turbo 140hp	103	4900- 6000	82. 6	72. 5	25.75	Petrol	200	9.5	4	4	1364
SEAT Leon III 1.4 TSI 150hp	110	5000- 6000	80	74. 5	27.5	Petrol	250	10.5	4	4	1395
SEAT Exeo 1.8 TSI 160hp	118	4500- 6200	84. 2	82. 5	29.5	Petrol	250	9.6	4	4	1798
VW Golf VI 1.4 TSI 140hp	103	5600	75. 6	76	25.75	Petrol	220	10	4	4	1390
VW Jetta VI 1.4TSI 150hp	110	5800	75. 6	76. 5	27.5	Petrol	250	10	4	4	1395
Fiat Spider 1.4 Multi-air 140hp	103	5000	84	72	25.75	Petrol	240	9.8	4	4	1368

The chosen engine for the project is the one used for VW Passat B8 1,4 TSI 150hp, model 2014-2018.

## ***Thermal calculation***

Thermal calculation has as a goal the determination of the P-V diagram that will be traced during engine operation and of the fundamental dimensions of the engine together with the main efficiency parameters. When designing a new engine, the performances that need to be reached are firstly set, considering the destination of the engine and its worldwide development state. Thus, it is rational that the thermal calculus is to be started from the new engines power per unit displacement

For the selected engine, the initial data is:

Stroke	80	mm
Bore	74.5	mm
$\varepsilon$	10.5	
$\tau$	4	
n	5000	rpm
Pe	110	kW

When designing a new engine, the performances that need to be reached are firstly set, considering the destination of the engine and its worldwide development state. Thus, it is rational that the thermal calculus is to be started from the new engines power per unit displacement. Using the formula below, the engine displacement it is calculated:

$$V_s = \frac{P_e}{i \cdot P_l} \text{ [dm}^3\text{]}$$

$$V_s = 0.350 \text{ dm}^3$$

$$i = 4$$

$$T_0 = 298 \text{ K}$$

$$P_l = 79 \text{ kW/dm}^3$$

The following step is to calculate the mean effective pressure using the following formula:

$$p_e = \frac{30 \cdot \tau \cdot P_e}{i \cdot V_s \cdot n} \text{ [MPa]}$$

Mean effective pressure	
pe	1.90Mpa

Estimating beforehand the mechanical efficiency, using the indications from table 2, the value of the mean indicated pressure can be obtained:

$$p_i = \frac{1}{\eta_m} \cdot p_e \text{ [MPa]}$$

ENGINE TYPE			$\eta_m$
SIE	4 strokes	$n = 1000 \dots 2000 \text{ rot/min}$	0.87...0.70
		$n = 2000 \dots 4000 \text{ rot/min}$	0.78...0.66
		$n = 4000 \dots 8000 \text{ rot/min}$	0.75...0.60
CIE	2 strokes	$n = 3000 \dots 5000 \text{ rot/min}$	0.80...0.68
	4 strokes	normal aspirated	0.82...0.75
		supercharged	0.90...0.80
	2 strokes	normal aspirated	0.80...0.70
		supercharged	0.90...0.75

Where in our case  $n=5000 \text{ rpm}$ , and  $\eta_m$  will be selected as 0.75.

Mean indicated pressure		Mechanical efficiency		
pi	2.52	MPa	$\eta_m$	0.75

S/D ratio	
$\psi$	1.07

The mean piston speed was determined as:

$$\bar{w}_p = \frac{S \cdot n}{30} \cdot 10^{-3} \text{ [m/s]}$$

wp	13	m/s
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It follows the rule in the following table

ENGINE TYPE			$\bar{w}_p$ [m/s]
SIE	4 strokes	passenger cars	12...15
		racing	15...23
		trucks and automobiles	9...12
CIE	4 strokes	trucks and passenger cars	7...13
		tractors	5.5...10.5
		railway traction	9...12
	2 strokes	naval and medium speed	8...9
		semi fast railway traction	7...8
		low speed naval traction	5...7

For engines with forced intake in 2 strokes or supercharged, the pressure and temperature from the engine's intake are the pressure and temperature from the compressor's exit.

Depending on the type of supercharging, the pressure at the compressor outlet is shown in table 5.

Table 5

SUPERCHARGING TYPE	$p_z$ [bar]
Low pressure supercharging	(1.2...1.5)
Medium supercharging	(1.5...2.2)
High supercharging	(2.2...3.5)
Very high supercharging	(3.5...6.0)

For passenger cars and tractors:  $p_z \leq 2.5 \cdot p_0$

The engine is supercharged, as a result the parameters are:

$p_s$	2.2	bar	0.22	MPa
$T_s$	373	K		
$m_s$	1.4			

The rounding parameters:

$$\begin{cases} \eta_d = 0,94 \dots 0,97 \\ \eta_p = 0,75 \dots 0,85 \end{cases}$$

$\eta_d$	0.97
$\eta_p$	0.75

Using the supercharging pressure, the intake and exhaust pressures were calculated as:

$p_a$	0.198	MPa	$p_{ev}$	0.176	MPa
$p_0$	0.1	MPa			

Mean polytropic index of compression	
$m_c$	1.32
Mean polytropic index of expansion	
$m_d$	1.28

The gas temperature at the end of the intake was taken as:

Table 9

ENGINE TYPE	$T_a$ [K]
SIE	320...370
CIE	310...350
Supercharged engine	320...350

$T_a$	350 K
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State parameters at the end of compression:

$p_c$	4.4	MPa
$T_c$	742.8	K

Mean indicated pressures:

$p_i'$	2.58	MPa
$p_i$	2.5234	MPa

Ratio of pressure rise during combustion using the parameter  $\rho$ :

$$\lambda_p := \frac{\frac{\varepsilon - 1}{m_c} \cdot \left( \frac{p_{i1}}{p_a} \right) + \frac{1}{m_c - 1} \cdot \left( 1 - \frac{1}{\varepsilon^{m_c - 1}} \right)}{(\rho - 1) + \frac{\rho}{(m_d - 1)} \cdot \left[ 1 - \left( \frac{\rho}{\varepsilon} \right)^{m_d - 1} \right]} = 2.581$$

$\lambda_p$	2.6241
$\rho$	1.5

Maximum pressure of the theoretic cycle

$p_z=11.6\text{MPa}$

In the end, the maximum pressure after modifying the  $\rho$  parameter, has resulted as:

$p_{\max}$	8.7	MPa
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which is higher than the indicated limit.

*Table 10*

ENGINE TYPE		$p_{\max} [\text{MPa}] \uparrow$
SIE		3... 6.5
CIE	normally aspirated	8...12.0
	supercharged	9...15.0

## ***Combustion calculation***

The fuel burning inside the engine cylinders is defined by the mass fractions of its carbon (*c*), hydrogen (*h*) and oxygen (*o*) content. Thus, the specific fuel for vehicle engines, gasoline, is characterized by the following mean compositions:

c	0.854	kgC/kgfuel
h	0.142	kgH <sub>2</sub> /kgfuel
o	0.004	kgO <sub>2</sub> /kgfuel

Then the minimum air quantity for a complete combustion of 1 kg of fuel was determined:

L <sub>0</sub>	0.5073	kmolair/kmolfuel
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Fuel gas composition depends on the relative air-fuel ratio,  $\lambda$ :

$\lambda$	0.9000
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Molar composition of combustion:

N <sub>CO<sub>2</sub></sub>	0.04985833	kmolCO <sub>2</sub> /kgFuel
N <sub>CO</sub>	0.02130833	kmolH <sub>2</sub> O/kgFuel
N <sub>H<sub>2</sub>O</sub>	0.071	kmolO <sub>2</sub> /kgFuel
N <sub>N<sub>2</sub></sub>	0.36071964	kmolN <sub>2</sub> /kgFuel
Mc	114	kg/kmol

Initial amount of fresh mixture:

N <sub>1</sub>	0.4654	kmolAir/kmolFuel
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Final quantity of burned gases:



N2	0.50288631	kmol burned g/kgFuel
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Chemical coefficient of molar variation:

$\mu_0$	1.080595023
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Number of kilomoles of residual burned gases:

Nr	7.06446E-07	Kilomoles of burned gases/cycle
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Parameters:

Vc	0.0367	dm <sup>3</sup>
R	8314	J/kmolK
Tr	1100	K

The number of kilomoles of initial mixture was computed in a similar manner:

Na	2.62268E-05	kmoles/cycle
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Kilomoles of fresh mixture:

Npr	2.55204E-05	kmoles/cycle
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With all the previous data , the residual burned gases coefficient, filling coefficient and the total molar variation coefficient were computed:

Residual burned gases coefficient					
$\gamma_r$	0.0277				
Filling coefficient					
$\eta_v$	1.03				
Total molar variation coefficient					
$\mu$	1.078				
			N <sub>ga</sub>	2.7577E-05	kmoles/cycle

The resulted temperature at the end of combustion:

Tz	2711	K
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which is between the requested limits

Energy balance

Internal energies computed using the graph for SIE engines:

u <sub>zg</sub> [kJ/kmol]	u <sub>cg</sub> [kJ/kmol]	u <sub>cpr</sub> [kJ/kmol]
78884.84	17051.4	15922.82

Using the internal energies, I computed the specific internal energies

U <sub>z</sub>	U <sub>c</sub>
2.231147962	0.418401828

Economy indices of the engine can be computed through the relations:

– fuel consumption per hour

$$C_e = G_{ciclu} \cdot i \cdot \frac{2 \cdot n}{\tau} \cdot 60 \cdot 10^{-3} = 0,12 \cdot G_{ciclu} \cdot \frac{i \cdot n}{\tau} \quad [\text{kg/h}] \quad (46)$$

– brake specific fuel consumption

$$c_e = \frac{C_e}{P_e} \cdot 10^3 \quad [\text{g/kwh}] \quad (47)$$

– brake fuel conversion efficiency

$$\eta_e = \frac{3,6 \cdot 10^6}{c_e \cdot Q_i} \quad (48)$$

The fuel quantity that can be burned completely inside the cylinder during a cycle is:

$G_{0 \text{ cycle}}$	0.050302137	g
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and that which burns with the relative air-fuel ratio:

$G_{\text{cycle}}$	0.055891263	g
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The heat quantity that can be theoretically released through the burning of this fuel quantity:

$Q_{\text{cycle}}$	1.812746135	kJ/cycle
$Q_{\text{cycle}}^t [\text{kJ}]$	2.157653015	kJ

Parameters for computation:

$Q_i$	43955	kJ/kg	Inferior calorific power of the used fuel
$Q_{\text{CO}}$	251100	kJ/kmol	Molar calorific power of the carbon oxide

Cylinder volume at the end of combustion:

$V_z$	0.0367	dm <sup>3</sup>
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The usage coefficient of the heat released through the fuel burning in the cylinder:

$\xi_u$	0.840147198	<0.95
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State parameters at the end of expansion		
$p_d$	0.96	MPa
$T_d$	1572	K

The fuel consumption per hour:

$C_e$	33.5	kg/h
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Break specific fuel consumption:

$c_e$	304.9	g/kwh
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Brake fuel conversion efficiency:

$\eta_e$	0.27
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## ***Engine thermal balance***

Using the specific internal energies computed at T0 and Q<sub>ge</sub> :

u <sub>ge</sub>	u <sub>pr</sub>
[kJ/kg]	[kJ/kg]
31000	6400

the heat parameters were computed

T <sub>ge</sub>	1336	K
i <sub>ge</sub>	42108.31	kJ/kmol
i <sub>pr</sub>	8877.572	kJ/kmol
Q <sub>ge</sub>	17044.25	kJ/kmol
Q <sub>rp</sub>	3936.214484	kJ/kg
Q <sub>e</sub>	11808.64345	kJ/kg
Q <sub>in</sub>	37866.90476	kJ/kg
ΔQ <sub>in</sub>	6088.095238	kJ/kg
Δq <sub>in</sub>	10	
q <sup>*</sup> <sub>ge</sub>	38.8	%
q <sub>e</sub>	26.9	%
q <sub>rez</sub>	4.56	%
q <sup>t</sup> <sub>cycle</sub>	100	%
q <sup>*</sup> <sub>rac</sub>	20	%
Q <sup>*</sup> <sub>rac</sub>	0.16802944	

Mean exhaust gases temperature

Exhaust gases enthalpy

η <sub>i</sub>	0.358
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## ***p-V Diagram***

This diagram is used to determine the perfection parameters of the cycle (indicated efficiency, indicated specific fuel consumption and indicated mean pressure), and also in the computations of the mechanical and thermal stresses of the engine components.

Taking the crank radius,  $r$ , and the length of the connecting rod,  $l$ , the  $p$ - $V$  diagram at different crank angle degrees can be developed.

$r$	40	mm
$l$	124	mm
$\Lambda$	0.322581	

$\alpha$ [CAD]	$\alpha$ [rad]	$s(\alpha)$	$V(\alpha)$ [dm <sup>3</sup> ]	$p(\alpha)$ th [MPa]	$p(\alpha)$ real [MPa]	$\Delta V_i$ [dm <sup>3</sup> ]
0	0	0	0.0410274	0.198	0.198	3.511E-05
1	0.017453	0.008057	0.0410625	0.198	0.198	0.0001054
2	0.034907	0.032225	0.0411678	0.198	0.198	0.0001724
3	0.05236	0.072491	0.0413434	0.198	0.198	0.0002445
4	0.069813	0.128835	0.041589	0.198	0.198	0.00031594
5	0.087266	0.201229	0.0419045	0.198	0.198	0.0003823
6	0.10472	0.289636	0.0422901	0.198	0.198	0.000419
7	0.122173	0.394011	0.0427455	0.198	0.198	0.0005309
8	0.139626	0.514303	0.0432699	0.198	0.198	0.0005982
9	0.15708	0.650449	0.0438616	0.198	0.198	0.0006668
10	0.174533	0.802383	0.0445249	0.198	0.198	0.0007301
11	0.191986	0.970026	0.0452533	0.198	0.198	0.0007992
12	0.20944	1.153296	0.04605744	0.198	0.198	0.0008685
13	0.226893	1.352099	0.0469214	0.198	0.198	0.0009339
14	0.244346	1.566336	0.0478553	0.198	0.198	0.0010007
15	0.261799	1.795899	0.048856	0.198	0.198	0.001067
16	0.279253	2.040672	0.049923	0.198	0.198	0.0011328
17	0.296706	2.300533	0.0510557	0.198	0.198	0.001198
18	0.314159	2.575352	0.0522537	0.198	0.198	0.0012626
19	0.331613	2.864989	0.0535163	0.198	0.198	0.0013265

20	0.349066	3.169301	0.0548428	0.198	0.198	0.0013898
21	0.366519	3.488135	0.0562327	0.198	0.198	0.0014525
22	0.383972	3.821331	0.0576851	0.198	0.198	0.0015143
23	0.401426	4.168722	0.0591995	0.198	0.198	0.0015755
24	0.418879	4.530136	0.0607749	0.198	0.198	0.0016358
25	0.436332	4.905391	0.0624107	0.198	0.198	0.0016953
26	0.453786	5.294301	0.064106	0.198	0.198	0.001754
27	0.471239	5.696671	0.06586	0.198	0.198	0.0018118
28	0.488692	6.112303	0.0676718	0.198	0.198	0.0018687
29	0.506145	6.540988	0.0695405	0.198	0.198	0.0019247
30	0.523599	6.982516	0.0714652	0.198	0.198	0.0019797
31	0.541052	7.436666	0.0734449	0.198	0.198	0.0020338
32	0.558505	7.903214	0.0754787	0.198	0.198	0.0020868
33	0.575959	8.38193	0.0775655	0.198	0.198	0.0021388
34	0.593412	8.872579	0.0797043	0.198	0.198	0.0021898
35	0.610865	9.374917	0.0818941	0.198	0.198	0.0022397
36	0.628319	9.8887	0.0841337	0.198	0.198	0.0022884
37	0.645772	10.41367	0.0864222	0.198	0.198	0.0023361
38	0.663225	10.94958	0.0887583	0.198	0.198	0.0023826
39	0.680678	11.49617	0.0911409	0.198	0.198	0.002428
40	0.698132	12.05316	0.093569	0.198	0.198	0.0024722
41	0.715585	12.62029	0.0960412	0.198	0.198	0.0025152
42	0.733038	13.19728	0.0985563	0.198	0.198	0.002557
43	0.750492	13.78385	0.1011133	0.198	0.198	0.0025975
44	0.767945	14.37973	0.1037108	0.198	0.198	0.0026368
45	0.785398	14.98462	0.1063477	0.198	0.198	0.0026749
46	0.802851	15.59824	0.1090225	0.198	0.198	0.0027116
47	0.820305	16.22029	0.1117341	0.198	0.198	0.0027471
48	0.837758	16.85049	0.1144813	0.198	0.198	0.0027813
49	0.855211	17.48852	0.1172625	0.198	0.198	0.0028141
50	0.872665	18.13409	0.1200767	0.198	0.198	0.0028457
51	0.890118	18.7869	0.1229224	0.198	0.198	0.0028759
52	0.907571	19.44664	0.1257983	0.198	0.198	0.0029048
53	0.925025	20.113	0.1287031	0.198	0.198	0.0029323
54	0.942478	20.78568	0.1316354	0.198	0.198	0.0029585
55	0.959931	21.46437	0.1345939	0.198	0.198	0.0029833
56	0.977384	22.14875	0.1375772	0.198	0.198	0.0030068
57	0.994838	22.83852	0.140584	0.198	0.198	0.0030289
58	1.012291	23.53335	0.1436129	0.198	0.198	0.0030496
59	1.029744	24.23295	0.1466626	0.198	0.198	0.003069
60	1.047198	24.93699	0.1497316	0.198	0.198	0.003087

61	1.064651	25.64516	0.1528186	0.198	0.198	0.0031037
62	1.082104	26.35716	0.1559223	0.198	0.198	0.003119
63	1.099557	27.07266	0.1590413	0.198	0.198	0.0031329
64	1.117011	27.79135	0.1621742	0.198	0.198	0.0031455
65	1.134464	28.51294	0.1653197	0.198	0.198	0.0031567
66	1.151917	29.23709	0.1684764	0.198	0.198	0.0031666
67	1.169371	29.96352	0.171643	0.198	0.198	0.0031752
68	1.186824	30.69191	0.1748182	0.198	0.198	0.0031824
69	1.204277	31.42196	0.1780006	0.198	0.198	0.0031883
70	1.22173	32.15336	0.1811889	0.198	0.198	0.0031929
71	1.239184	32.88582	0.1843818	0.198	0.198	0.0031962
72	1.256637	33.61904	0.187578	0.198	0.198	0.0031983
73	1.27409	34.35273	0.1907763	0.198	0.198	0.003199
74	1.291544	35.08659	0.1939753	0.198	0.198	0.0031985
75	1.308997	35.82033	0.1971738	0.198	0.198	0.0031968
76	1.32645	36.55368	0.2003706	0.198	0.198	0.0031938
77	1.343904	37.28635	0.2035644	0.198	0.198	0.0031896
78	1.361357	38.01806	0.206754	0.198	0.198	0.0031843
79	1.37881	38.74854	0.2099383	0.198	0.198	0.0031777
80	1.396263	39.47752	0.213116	0.198	0.198	0.00317
81	1.413717	40.20473	0.2162861	0.198	0.198	0.0031612
82	1.43117	40.92992	0.2194473	0.198	0.198	0.0031513
83	1.448623	41.65283	0.2225986	0.198	0.198	0.0031402
84	1.466077	42.37321	0.2257388	0.198	0.198	0.0031281
85	1.48353	43.0908	0.2288669	0.198	0.198	0.0031149
86	1.500983	43.80537	0.2319818	0.198	0.198	0.0031007
87	1.518436	44.51669	0.2350825	0.198	0.198	0.0030855
88	1.53589	45.22451	0.2381681	0.198	0.198	0.0030693
89	1.553343	45.92862	0.2412374	0.198	0.198	0.0030522
90	1.570796	46.62879	0.2442895	0.198	0.198	0.0030341
91	1.58825	47.32481	0.2473236	0.198	0.198	0.003015
92	1.605703	48.01647	0.2503387	0.198	0.198	0.0029951
93	1.623156	48.70356	0.2533338	0.198	0.198	0.0029744
94	1.640609	49.38589	0.2563082	0.198	0.198	0.0029528
95	1.658063	50.06326	0.2592609	0.198	0.198	0.0029303
96	1.675516	50.73548	0.2621912	0.198	0.198	0.0029071
97	1.692969	51.40238	0.2650984	0.198	0.198	0.0028831
98	1.710423	52.06377	0.2679815	0.198	0.198	0.0028584
99	1.727876	52.71949	0.2708399	0.198	0.198	0.0028329
100	1.745329	53.36937	0.2736728	0.198	0.198	0.0028068
101	1.762783	54.01326	0.2764796	0.198	0.198	0.00278

102	1.780236	54.65099	0.2792596	0.198	0.198	0.0027525
103	1.797689	55.28243	0.2820121	0.198	0.198	0.0027245
104	1.815142	55.90743	0.2847366	0.198	0.198	0.0026958
105	1.832596	56.52586	0.2874324	0.198	0.198	0.0026666
106	1.850049	57.13757	0.290099	0.198	0.198	0.0026368
107	1.867502	57.74246	0.2927358	0.198	0.198	0.0026065
108	1.884956	58.3404	0.2953423	0.198	0.198	0.0025757
109	1.902409	58.93127	0.297918	0.198	0.198	0.0025444
110	1.919862	59.51497	0.3004624	0.198	0.198	0.0025127
111	1.937315	60.09139	0.3029751	0.198	0.198	0.0024806
112	1.954769	60.66044	0.3054557	0.198	0.198	0.002448
113	1.972222	61.22201	0.3079037	0.198	0.198	0.002415
114	1.989675	61.77602	0.3103187	0.198	0.198	0.0023817
115	2.007129	62.3224	0.3127004	0.198	0.198	0.0023481
116	2.024582	62.86105	0.3150485	0.198	0.198	0.0023141
117	2.042035	63.3919	0.3173625	0.198	0.198	0.0022798
118	2.059489	63.91488	0.3196423	0.198	0.198	0.0022452
119	2.076942	64.42993	0.3218875	0.198	0.198	0.0022103
120	2.094395	64.93699	0.3240978	0.198	0.198	0.0021752
121	2.111848	65.436	0.3262731	0.198	0.198	0.0021399
122	2.129302	65.9269	0.328413	0.198	0.198	0.0021044
123	2.146755	66.40964	0.3305173	0.198	0.198	0.0020686
124	2.164208	66.88418	0.3325859	0.198	0.198	0.0020327
125	2.181662	67.35048	0.3346186	0.198	0.198	0.0019966
126	2.199115	67.8085	0.3366152	0.198	0.198	0.0019603
127	2.216568	68.2582	0.3385755	0.198	0.198	0.0019239
128	2.234021	68.69955	0.3404994	0.198	0.198	0.0018874
129	2.251475	69.13253	0.3423868	0.198	0.198	0.0018508
130	2.268928	69.5571	0.3442376	0.198	0.198	0.001814
131	2.286381	69.97324	0.3460516	0.198	0.198	0.0017772
132	2.303835	70.38093	0.3478288	0.198	0.198	0.0017403
133	2.321288	70.78016	0.3495691	0.198	0.198	0.0017033
134	2.338741	71.17091	0.3512725	0.198	0.198	0.0016663
135	2.356194	71.55317	0.3529388	0.198	0.198	0.0016292
136	2.373648	71.92691	0.354568	0.198	0.198	0.0015921
137	2.391101	72.29215	0.3561601	0.198	0.198	0.001555
138	2.408554	72.64886	0.3577151	0.198	0.198	0.0015178
139	2.426008	72.99705	0.3592329	0.198	0.198	0.0014806
140	2.443461	73.33671	0.3607135	0.198	0.198	0.0014434
141	2.460914	73.66784	0.362157	0.198	0.198	0.0014063
142	2.478368	73.99044	0.3635633	0.198	0.198	0.0013691



143	2.495821	74.30451	0.3649323	0.198	0.198	0.0013319
144	2.513274	74.61006	0.3662643	0.198	0.198	0.0012948
145	2.530727	74.90708	0.367559	0.198	0.198	0.0012576
146	2.548181	75.19558	0.3688166	0.198	0.198	0.0012205
147	2.565634	75.47558	0.3700372	0.198	0.198	0.0011834
148	2.583087	75.74706	0.3712206	0.198	0.198	0.0011464
149	2.600541	76.01005	0.372367	0.198	0.198	0.0011094
150	2.617994	76.26455	0.3734764	0.198	0.198	0.0010724
151	2.635447	76.51056	0.3745489	0.198	0.198	0.0010355
152	2.6529	76.74811	0.3755843	0.198	0.198	0.0009986
153	2.670354	76.97719	0.376583	0.198	0.198	0.0009618
154	2.687807	77.19782	0.3775447	0.198	0.198	0.000925
155	2.70526	77.41001	0.3784697	0.198	0.198	0.0008882
156	2.722714	77.61377	0.3793579	0.198	0.198	0.0008515
157	2.740167	77.80911	0.3802094	0.198	0.198	0.0008149
158	2.75762	77.99604	0.3810243	0.198	0.198	0.0007782
159	2.775074	78.17457	0.3818025	0.198	0.198	0.0007417
160	2.792527	78.34471	0.3825442	0.198	0.198	0.0007052
161	2.80998	78.50648	0.3832493	0.198	0.198	0.0006687
162	2.827433	78.65987	0.383918	0.198	0.198	0.0006323
163	2.844887	78.80491	0.3845503	0.198	0.198	0.0005959
164	2.86234	78.94161	0.3851461	0.198	0.198	0.0005595
165	2.879793	79.06996	0.3857057	0.198	0.198	0.0005232
166	2.897247	79.18999	0.3862289	0.198	0.198	0.000487
167	2.9147	79.3017	0.3867159	0.198	0.198	0.0004507
168	2.932153	79.4051	0.3871666	0.198	0.198	0.0004145
169	2.949606	79.5002	0.3875811	0.198	0.198	0.0003784
170	2.96706	79.587	0.3879595	0.198	0.198	0.0003423
171	2.984513	79.66552	0.3883018	0.198	0.198	0.0003062
172	3.001966	79.73575	0.3886079	0.198	0.198	0.0002701
173	3.01942	79.7977	0.388878	0.198	0.198	0.000234
174	3.036873	79.85139	0.389112	0.198	0.198	0.000198
175	3.054326	79.8968	0.38931	0.198	0.198	0.000162
176	3.071779	79.93396	0.389472	0.198	0.198	0.000126
177	3.089233	79.96285	0.3895979	0.198	0.198	8.996E-05
178	3.106686	79.98349	0.3896879	0.198	0.198	5.397E-05
179	3.124139	79.99587	0.3897419	0.198	0.198	1.799E-05
180	3.141593	80	0.3897598	0.198	0.198	-1.8E-05
181	3.159046	79.99587	0.3897419	0.198012065	0.198012065	-5.4E-05
182	3.176499	79.98349	0.3896879	0.198048267	0.198048267	-9E-05
183	3.193953	79.96285	0.3895979	0.198108634	0.198108634	-0.000126

184	3.211406	79.93396	0.389472	0.198193209	0.198193209	-0.000162
185	3.228859	79.8968	0.38931	0.198302055	0.198302055	-0.000198
186	3.246312	79.85139	0.389112	0.198435249	0.198435249	-0.000234
187	3.263766	79.7977	0.388878	0.19859289	0.19859289	-0.00027
188	3.281219	79.73575	0.3886079	0.198775093	0.198775093	-0.000306
189	3.298672	79.66552	0.3883018	0.198981991	0.198981991	-0.000342
190	3.316126	79.587	0.3879595	0.199213736	0.199213736	-0.000378
191	3.333579	79.5002	0.3875811	0.199470497	0.199470497	-0.000415
192	3.351032	79.4051	0.3871666	0.199752464	0.199752464	-0.000451
193	3.368485	79.3017	0.3867159	0.200059845	0.200059845	-0.000487
194	3.385939	79.18999	0.3862289	0.200392866	0.200392866	-0.000523
195	3.403392	79.06996	0.3857057	0.200751775	0.200751775	-0.00056
196	3.420845	78.94161	0.3851461	0.201136837	0.201136837	-0.000596
197	3.438299	78.80491	0.3845503	0.201548339	0.201548339	-0.000632
198	3.455752	78.65987	0.383918	0.201986589	0.201986589	-0.000669
199	3.473205	78.50648	0.3832493	0.202451915	0.202451915	-0.000705
200	3.490659	78.34471	0.3825442	0.202944666	0.202944666	-0.000742
201	3.508112	78.17457	0.3818025	0.203465215	0.203465215	-0.000778
202	3.525565	77.99604	0.3810243	0.204013955	0.204013955	-0.000815
203	3.543018	77.80911	0.3802094	0.204591303	0.204591303	-0.000852
204	3.560472	77.61377	0.3793579	0.205197701	0.205197701	-0.000888
205	3.577925	77.41001	0.3784697	0.205833612	0.205833612	-0.000925
206	3.595378	77.19782	0.3775447	0.206499526	0.206499526	-0.000962
207	3.612832	76.97719	0.376583	0.207195958	0.207195958	-0.000999
208	3.630285	76.74811	0.3755843	0.20792345	0.20792345	-0.001035
209	3.647738	76.51056	0.3745489	0.208682568	0.208682568	-0.001072
210	3.665191	76.26455	0.3734764	0.20947391	0.20947391	-0.001109
211	3.682645	76.01005	0.372367	0.210298098	0.210298098	-0.001146
212	3.700098	75.74706	0.3712206	0.211155787	0.211155787	-0.001183
213	3.717551	75.47558	0.3700372	0.212047661	0.212047661	-0.001221
214	3.735005	75.19558	0.3688166	0.212974435	0.212974435	-0.001258
215	3.752458	74.90708	0.367559	0.213936856	0.213936856	-0.001295
216	3.769911	74.61006	0.3662643	0.214935708	0.214935708	-0.001332
217	3.787364	74.30451	0.3649323	0.215971804	0.215971804	-0.001369
218	3.804818	73.99044	0.3635633	0.217045997	0.217045997	-0.001406
219	3.822271	73.66784	0.362157	0.218159176	0.218159176	-0.001443
220	3.839724	73.33671	0.3607135	0.219312269	0.219312269	-0.001481
221	3.857178	72.99705	0.3592329	0.220506242	0.220506242	-0.001518
222	3.874631	72.64886	0.3577151	0.221742103	0.221742103	-0.001555
223	3.892084	72.29215	0.3561601	0.223020905	0.223020905	-0.001592
224	3.909538	71.92691	0.354568	0.224343743	0.224343743	-0.001629

225	3.926991	71.55317	0.3529388	0.225711759	0.225711759	-0.001666
226	3.944444	71.17091	0.3512725	0.227126143	0.227126143	-0.001703
227	3.961897	70.78016	0.3495691	0.228588135	0.228588135	-0.00174
228	3.979351	70.38093	0.3478288	0.230099028	0.230099028	-0.001777
229	3.996804	69.97324	0.3460516	0.231660166	0.231660166	-0.001814
230	4.014257	69.5571	0.3442376	0.233272953	0.233272953	-0.001851
231	4.031711	69.13253	0.3423868	0.234938848	0.234938848	-0.001887
232	4.049164	68.69955	0.3404994	0.236659372	0.236659372	-0.001924
233	4.066617	68.2582	0.3385755	0.238436112	0.238436112	-0.00196
234	4.08407	67.8085	0.3366152	0.240270717	0.240270717	-0.001997
235	4.101524	67.35048	0.3346186	0.242164908	0.242164908	-0.002033
236	4.118977	66.88418	0.3325859	0.244120476	0.244120476	-0.002069
237	4.13643	66.40964	0.3305173	0.246139289	0.246139289	-0.002104
238	4.153884	65.9269	0.328413	0.248223292	0.248223292	-0.00214
239	4.171337	65.436	0.3262731	0.250374512	0.250374512	-0.002175
240	4.18879	64.93699	0.3240978	0.252595062	0.252595062	-0.00221
241	4.206243	64.42993	0.3218875	0.254887143	0.254887143	-0.002245
242	4.223697	63.91488	0.3196423	0.257253052	0.257253052	-0.00228
243	4.24115	63.3919	0.3173625	0.25969518	0.25969518	-0.002314
244	4.258603	62.86105	0.3150485	0.262216022	0.262216022	-0.002348
245	4.276057	62.3224	0.3127004	0.26481818	0.26481818	-0.002382
246	4.29351	61.77602	0.3103187	0.267504369	0.267504369	-0.002415
247	4.310963	61.22201	0.3079037	0.270277417	0.270277417	-0.002448
248	4.328417	60.66044	0.3054557	0.273140279	0.273140279	-0.002481
249	4.34587	60.09139	0.3029751	0.276096036	0.276096036	-0.002513
250	4.363323	59.51497	0.3004624	0.279147903	0.279147903	-0.002544
251	4.380776	58.93127	0.297918	0.282299238	0.282299238	-0.002576
252	4.39823	58.3404	0.2953423	0.285553546	0.285553546	-0.002607
253	4.415683	57.74246	0.2927358	0.288914486	0.288914486	-0.002637
254	4.433136	57.13757	0.290099	0.292385883	0.292385883	-0.002667
255	4.45059	56.52586	0.2874324	0.295971729	0.295971729	-0.002696
256	4.468043	55.90743	0.2847366	0.299676197	0.299676197	-0.002724
257	4.485496	55.28243	0.2820121	0.303503649	0.303503649	-0.002753
258	4.502949	54.65099	0.2792596	0.307458644	0.307458644	-0.00278
259	4.520403	54.01326	0.2764796	0.311545949	0.311545949	-0.002807
260	4.537856	53.36937	0.2736728	0.31577055	0.31577055	-0.002833
261	4.555309	52.71949	0.2708399	0.320137661	0.320137661	-0.002858
262	4.572763	52.06377	0.2679815	0.32465274	0.32465274	-0.002883
263	4.590216	51.40238	0.2650984	0.329321496	0.329321496	-0.002907
264	4.607669	50.73548	0.2621912	0.334149907	0.334149907	-0.00293
265	4.625123	50.06326	0.2592609	0.339144233	0.339144233	-0.002953

266	4.642576	49.38589	0.2563082	0.344311028	0.344311028	-0.002974
267	4.660029	48.70356	0.2533338	0.349657159	0.349657159	-0.002995
268	4.677482	48.01647	0.2503387	0.35518982	0.35518982	-0.003015
269	4.694936	47.32481	0.2473236	0.360916551	0.360916551	-0.003034
270	4.712389	46.62879	0.2442895	0.366845256	0.366845256	-0.003052
271	4.729842	45.92862	0.2412374	0.372984224	0.372984224	-0.003069
272	4.747296	45.22451	0.2381681	0.379342145	0.379342145	-0.003086
273	4.764749	44.51669	0.2350825	0.385928138	0.385928138	-0.003101
274	4.782202	43.80537	0.2319818	0.392751769	0.392751769	-0.003115
275	4.799655	43.0908	0.2288669	0.399823078	0.399823078	-0.003128
276	4.817109	42.37321	0.2257388	0.407152604	0.407152604	-0.00314
277	4.834562	41.65283	0.2225986	0.414751413	0.414751413	-0.003151
278	4.852015	40.92992	0.2194473	0.422631124	0.422631124	-0.003161
279	4.869469	40.20473	0.2162861	0.430803944	0.430803944	-0.00317
280	4.886922	39.47752	0.213116	0.439282694	0.439282694	-0.003178
281	4.904375	38.74854	0.2099383	0.448080848	0.448080848	-0.003184
282	4.921828	38.01806	0.206754	0.457212565	0.457212565	-0.00319
283	4.939282	37.28635	0.2035644	0.466692728	0.466692728	-0.003194
284	4.956735	36.55368	0.2003706	0.476536984	0.476536984	-0.003197
285	4.974188	35.82033	0.1971738	0.486761782	0.486761782	-0.003199
286	4.991642	35.08659	0.1939753	0.49738442	0.49738442	-0.003199
287	5.009095	34.35273	0.1907763	0.508423089	0.508423089	-0.003198
288	5.026548	33.61904	0.187578	0.51989692	0.51989692	-0.003196
289	5.044002	32.88582	0.1843818	0.531826037	0.531826037	-0.003193
290	5.061455	32.15336	0.1811889	0.544231603	0.544231603	-0.003188
291	5.078908	31.42196	0.1780006	0.557135883	0.557135883	-0.003182
292	5.096361	30.69191	0.1748182	0.570562291	0.570562291	-0.003175
293	5.113815	29.96352	0.171643	0.584535456	0.584535456	-0.003167
294	5.131268	29.23709	0.1684764	0.599081279	0.599081279	-0.003157
295	5.148721	28.51294	0.1653197	0.614226998	0.614226998	-0.003145
296	5.166175	27.79135	0.1621742	0.630001248	0.630001248	-0.003133
297	5.183628	27.07266	0.1590413	0.646434131	0.646434131	-0.003119
298	5.201081	26.35716	0.1559223	0.66355728	0.66355728	-0.003104
299	5.218534	25.64516	0.1528186	0.681403929	0.681403929	-0.003087
300	5.235988	24.93699	0.1497316	0.700008978	0.700008978	-0.003069
301	5.253441	24.23295	0.1466626	0.71940906	0.71940906	-0.00305
302	5.270894	23.53335	0.1436129	0.739642608	0.739642608	-0.003029
303	5.288348	22.83852	0.140584	0.76074992	0.76074992	-0.003007
304	5.305801	22.14875	0.1375772	0.782773217	0.782773217	-0.002983
305	5.323254	21.46437	0.1345939	0.805756696	0.805756696	-0.002959
306	5.340708	20.78568	0.1316354	0.829746586	0.829746586	-0.002932

307	5.358161	20.113	0.1287031	0.854791182	0.854791182	-0.002905
308	5.375614	19.44664	0.1257983	0.880940878	0.880940878	-0.002876
309	5.393067	18.7869	0.1229224	0.908248185	0.908248185	-0.002846
310	5.410521	18.13409	0.1200767	0.936767727	0.936767727	-0.002814
311	5.427974	17.48852	0.1172625	0.966556229	0.966556229	-0.002781
312	5.445427	16.85049	0.1144813	0.997672466	0.997672466	-0.002747
313	5.462881	16.22029	0.1117341	1.030177196	1.030177196	-0.002712
314	5.480334	15.59824	0.1090225	1.064133051	1.064133051	-0.002675
315	5.497787	14.98462	0.1063477	1.09960439	1.09960439	-0.002637
316	5.51524	14.37973	0.1037108	1.136657106	1.136657106	-0.002598
317	5.532694	13.78385	0.1011133	1.175358373	1.175358373	-0.002557
318	5.550147	13.19728	0.0985563	1.215776331	1.215776331	-0.002515
319	5.5676	12.62029	0.0960412	1.257979701	1.257979701	-0.002472
320	5.585054	12.05316	0.093569	1.302037305	1.302037305	-0.002428
321	5.602507	11.49617	0.0911409	1.348017495	1.348017495	-0.002383
322	5.61996	10.94958	0.0887583	1.395987474	1.395987474	-0.002336
323	5.637413	10.41367	0.0864222	1.446012483	1.446012483	-0.002288
324	5.654867	9.8887	0.0841337	1.498154861	1.498154861	-0.00224
325	5.67232	9.374917	0.0818941	1.552472943	1.552472943	-0.00219
326	5.689773	8.872579	0.0797043	1.60901979	1.60901979	-0.002139
327	5.707227	8.38193	0.0775655	1.667841742	1.667841742	-0.002087
328	5.72468	7.903214	0.0754787	1.728976766	1.728976766	-0.002034
329	5.742133	7.436666	0.0734449	1.792452596	1.792452596	-0.00198
330	5.759587	6.982516	0.0714652	1.858284663	1.858284663	-0.001925
331	5.77704	6.540988	0.0695405	1.926473793	1.926473793	-0.001869
332	5.794493	6.112303	0.0676718	1.997003691	1.997003691	-0.001812
333	5.811946	5.696671	0.06586	2.069838212	2.069838212	-0.001754
334	5.8294	5.294301	0.064106	2.144918438	2.144918438	-0.001695
335	5.846853	4.905391	0.0624107	2.222159598	2.222159598	-0.001636
336	5.864306	4.530136	0.0607749	2.301447862	2.301447862	-0.001575
337	5.88176	4.168722	0.0591995	2.382637093	2.382637093	-0.001514
338	5.899213	3.821331	0.0576851	2.465545614	2.465545614	-0.001452
339	5.916666	3.488135	0.0562327	2.549953108	2.549953108	-0.00139
340	5.934119	3.169301	0.0548428	2.635597769	2.635597769	-0.001327
341	5.951573	2.864989	0.0535163	2.722173847	2.722173847	-0.001263
342	5.969026	2.575352	0.0522537	2.809329753	2.809329753	-0.001198
343	5.986479	2.300533	0.0510557	2.89666691	2.89666691	-0.001133
344	6.003933	2.040672	0.049923	2.983739538	2.983739538	-0.001067
345	6.021386	1.795899	0.048856	3.070055583	3.070055583	-0.001001
346	6.038839	1.566336	0.0478553	3.155078956	3.155078956	-0.000934
347	6.056293	1.352099	0.0469214	3.238233283	3.238233283	-0.000867

348	6.073746	1.153296	0.0460547	3.318907274	3.318907274	-0.000799
349	6.091199	0.970026	0.0452558	3.396461806	3.396461806	-0.000731
350	6.108652	0.802383	0.0445251	3.470238732	3.470238732	-0.000662
351	6.126106	0.650449	0.0438628	3.539571332	3.539571332	-0.000593
352	6.143559	0.514303	0.0432693	3.603796243	3.603796243	-0.000524
353	6.161012	0.394011	0.0427449	3.662266601	3.662266601	-0.000455
354	6.178466	0.289636	0.0422899	3.714365994	3.714365994	-0.000385
355	6.195919	0.201229	0.0419045	3.759522782	3.759522782	-0.000316
356	6.213372	0.128835	0.041589	3.797224219	3.797224219	-0.000246
357	6.230825	0.072491	0.0413434	3.827029797	3.827029797	-0.000176
358	6.248279	0.032225	0.0411678	3.848583196	3.848583196	-0.000105
359	6.265732	0.008057	0.0410625	3.861622281	3.861622281	-3.51E-05
360	6.283185	0	0.0410274	3.865986643	3.865986643	3.512E-05
361	6.300639	0.008057	0.0410625	11.6	11.5	0.0001054
362	6.318092	0.032225	0.0411678	11.6	11.51	0.0001755
363	6.335545	0.072491	0.0413434	11.53699923	11.52	0.0002456
364	6.352998	0.128835	0.041589	11.44985955	11.53	0.0003156
365	6.370452	0.201229	0.0419045	11.33960579	11.54	0.0003854
366	6.387905	0.289636	0.0422899	11.20750553	11.55	0.000455
367	6.405358	0.394011	0.0427449	11.05503507	11.56	0.0005244
368	6.422812	0.514303	0.0432693	10.88384145	11.57	0.0005935
369	6.440265	0.650449	0.0438628	10.69570215	11.6	0.0006623
370	6.457718	0.802383	0.0445251	10.49248428	11.59	0.0007308
371	6.475172	0.970026	0.0452558	10.2761046	11.58	0.0007989
372	6.492625	1.153296	0.0460547	10.04849194	11.57	0.0008666
373	6.510078	1.352099	0.0469214	9.8115529	11.56	0.0009339
374	6.527531	1.566336	0.0478553	9.567141782	11.55	0.0010007
375	6.544985	1.795899	0.048856	9.317035098	11.54	0.001067
376	6.562438	2.040672	0.049923	9.062911005	11.53	0.000901
376.8	6.576401	2.24736	0.0508239	8.857774396	11.52	0.0002318
377	6.579891	2.300533	0.0510557	8.806333582	11.51	0.001198
378	6.597345	2.575352	0.0522537	8.548741743	11.5	0.0012626
379	6.614798	2.864989	0.0535163	8.291442421	11	0.0013265
380	6.632251	3.169301	0.0548428	8.035607557	8.035607557	0.0013898
381	6.649704	3.488135	0.0562327	7.782274349	7.782274349	0.0014525
382	6.667158	3.821331	0.0576851	7.532348217	7.532348217	0.0015143
383	6.684611	4.168722	0.0591995	7.286607927	7.286607927	0.0015755
384	6.702064	4.530136	0.0607749	7.045712363	7.045712363	0.0016358
385	6.719518	4.905391	0.0624107	6.810208472	6.810208472	0.0016953
386	6.736971	5.294301	0.064106	6.580539977	6.580539977	0.001754
387	6.754424	5.696671	0.06586	6.357056483	6.357056483	0.0018118

388	6.771877	6.112303	0.0676718	6.140022716	6.140022716	0.0018687
389	6.789331	6.540988	0.0695405	5.929627621	5.929627621	0.0019247
390	6.806784	6.982516	0.0714652	5.72599318	5.72599318	0.0019797
391	6.824237	7.436666	0.0734449	5.529182777	5.529182777	0.0020338
392	6.841691	7.903214	0.0754787	5.33920905	5.33920905	0.0020868
393	6.859144	8.38193	0.0775655	5.156041147	5.156041147	0.0021388
394	6.876597	8.872579	0.0797043	4.979611372	4.979611372	0.0021898
395	6.894051	9.374917	0.0818941	4.809821206	4.809821206	0.0022397
396	6.911504	9.8887	0.0841337	4.646546716	4.646546716	0.0022884
397	6.928957	10.41367	0.0864222	4.489643365	4.489643365	0.0023361
398	6.94641	10.94958	0.0887583	4.33895027	4.33895027	0.0023826
399	6.963864	11.49617	0.0911409	4.194293926	4.194293926	0.002428
400	6.981317	12.05316	0.093569	4.055491454	4.055491454	0.0024722
401	6.99877	12.62029	0.0960412	3.9223534	3.9223534	0.0025152
402	7.016224	13.19728	0.0985563	3.794686138	3.794686138	0.002557
403	7.033677	13.78385	0.1011133	3.672293913	3.672293913	0.0025975
404	7.05113	14.37973	0.1037108	3.55498056	3.55498056	0.0026368
405	7.068583	14.98462	0.1063477	3.442550943	3.442550943	0.0026749
406	7.086037	15.59824	0.1090225	3.334812141	3.334812141	0.0027116
407	7.10349	16.22029	0.1117341	3.23157442	3.23157442	0.0027471
408	7.120943	16.85049	0.1144813	3.132652009	3.132652009	0.0027813
409	7.138397	17.48852	0.1172625	3.037863718	3.037863718	0.0028141
410	7.15585	18.13409	0.1200767	2.94703341	2.94703341	0.0028457
411	7.173303	18.7869	0.1229224	2.859990351	2.859990351	0.0028759
412	7.190757	19.44664	0.1257983	2.776569465	2.776569465	0.0029048
413	7.20821	20.113	0.1287031	2.696611494	2.696611494	0.0029323
414	7.225663	20.78568	0.1316354	2.619963086	2.619963086	0.0029585
415	7.243116	21.46437	0.1345939	2.546476831	2.546476831	0.0029833
416	7.26057	22.14875	0.1375772	2.476011233	2.476011233	0.0030068
417	7.278023	22.83852	0.140584	2.408430652	2.408430652	0.0030289
418	7.295476	23.53335	0.1436129	2.343605208	2.343605208	0.0030496
419	7.31293	24.23295	0.1466626	2.28141066	2.28141066	0.003069
420	7.330383	24.93699	0.1497316	2.221728266	2.221728266	0.003087
421	7.347836	25.64516	0.1528186	2.164444621	2.164444621	0.0031037
422	7.365289	26.35716	0.1559223	2.10945149	2.10945149	0.003119
423	7.382743	27.07266	0.1590413	2.056645631	2.056645631	0.0031329
424	7.400196	27.79135	0.1621742	2.005928613	2.005928613	0.0031455
425	7.417649	28.51294	0.1653197	1.957206627	1.957206627	0.0031567
426	7.435103	29.23709	0.1684764	1.910390303	1.910390303	0.0031666
427	7.452556	29.96352	0.171643	1.865394522	1.865394522	0.0031752
428	7.470009	30.69191	0.1748182	1.822138234	1.822138234	0.0031824

429	7.487462	31.42196	0.1780006	1.780544279	1.780544279	0.0031883
430	7.504916	32.15336	0.1811889	1.740539207	1.740539207	0.0031929
431	7.522369	32.88582	0.1843818	1.702053112	1.702053112	0.0031962
432	7.539822	33.61904	0.187578	1.665019459	1.665019459	0.0031983
433	7.557276	34.35273	0.1907763	1.62937493	1.62937493	0.003199
434	7.574729	35.08659	0.1939753	1.595059264	1.595059264	0.0031985
435	7.592182	35.82033	0.1971738	1.562015111	1.562015111	0.0031968
436	7.609636	36.55368	0.2003706	1.530187889	1.530187889	0.0031938
437	7.627089	37.28635	0.2035644	1.499525643	1.499525643	0.0031896
438	7.644542	38.01806	0.206754	1.469978921	1.469978921	0.0031843
439	7.661995	38.74854	0.2099383	1.441500641	1.441500641	0.0031777
440	7.679449	39.47752	0.213116	1.414045978	1.414045978	0.00317
441	7.696902	40.20473	0.2162861	1.387572247	1.387572247	0.0031612
442	7.714355	40.92992	0.2194473	1.362038796	1.362038796	0.0031513
443	7.731809	41.65283	0.2225986	1.337406901	1.337406901	0.0031402
444	7.749262	42.37321	0.2257388	1.313639673	1.313639673	0.0031281
445	7.766715	43.0908	0.2288669	1.290701958	1.290701958	0.0031149
446	7.784168	43.80537	0.2319818	1.268560254	1.268560254	0.0031007
447	7.801622	44.51669	0.2350825	1.247182626	1.247182626	0.0030855
448	7.819075	45.22451	0.2381681	1.226538627	1.226538627	0.0030693
449	7.836528	45.92862	0.2412374	1.20659922	1.20659922	0.0030522
450	7.853982	46.62879	0.2442895	1.187336711	1.187336711	0.0030341
451	7.871435	47.32481	0.2473236	1.168724676	1.168724676	0.003015
452	7.888888	48.01647	0.2503387	1.150737905	1.150737905	0.0029951
453	7.906342	48.70356	0.2533338	1.13335233	1.13335233	0.0029744
454	7.923795	49.38589	0.2563082	1.11654498	1.11654498	0.0029528
455	7.941248	50.06326	0.2592609	1.100293915	1.100293915	0.0029303
456	7.958701	50.73548	0.2621912	1.084578185	1.084578185	0.0029071
457	7.976155	51.40238	0.2650984	1.069377772	1.069377772	0.0028831
458	7.993608	52.06377	0.2679815	1.054673551	1.054673551	0.0028584
459	8.011061	52.71949	0.2708399	1.040447242	1.040447242	0.0028329
460	8.028515	53.36937	0.2736728	1.026681369	1.026681369	0.0028068
461	8.045968	54.01326	0.2764796	1.013359223	1.013359223	0.00278
462	8.063421	54.65099	0.2792596	1.000464823	1.000464823	0.0027525
463	8.080874	55.28243	0.2820121	0.987982882	0.987982882	0.0027245
464	8.098328	55.90743	0.2847366	0.975898773	0.975898773	0.0026958
465	8.115781	56.52586	0.2874324	0.964198496	0.964198496	0.0026666
466	8.133234	57.13757	0.290099	0.952868652	0.952868652	0.0026368
467	8.150688	57.74246	0.2927358	0.941896411	0.941896411	0.0026065
468	8.168141	58.3404	0.2953423	0.931269488	0.931269488	0.0025757
469	8.185594	58.93127	0.297918	0.920976113	0.920976113	0.0025444



470	8.203047	59.51497	0.3004624	0.911005015	0.911005015	0.0025127
471	8.220501	60.09139	0.3029751	0.901345389	0.901345389	0.0024806
472	8.237954	60.66044	0.3054557	0.891986885	0.891986885	0.002448
473	8.255407	61.22201	0.3079037	0.882919577	0.882919577	0.002415
474	8.272861	61.77602	0.3103187	0.874133953	0.874133953	0.0023817
475	8.290314	62.3224	0.3127004	0.865620889	0.865620889	0.0023481
476	8.307767	62.86105	0.3150485	0.857371636	0.857371636	0.0023141
477	8.325221	63.3919	0.3173625	0.849377803	0.849377803	0.0022798
478	8.342674	63.91488	0.3196423	0.841631338	0.841631338	0.0022452
479	8.360127	64.42993	0.3218875	0.834124518	0.834124518	0.0022103
480	8.37758	64.93699	0.3240978	0.826849931	0.826849931	0.0021752
481	8.395034	65.436	0.3262731	0.819800462	0.819800462	0.0021399
482	8.412487	65.9269	0.328413	0.812969283	0.812969283	0.0021044
483	8.42994	66.40964	0.3305173	0.806349841	0.806349841	0.0020686
484	8.447394	66.88418	0.3325859	0.799935843	0.799935843	0.0020327
485	8.464847	67.35048	0.3346186	0.793721247	0.793721247	0.0019966
486	8.4823	67.8085	0.3366152	0.787700254	0.787700254	0.0019603
487	8.499753	68.2582	0.3385755	0.781867291	0.781867291	0.0019239
488	8.517207	68.69955	0.3404994	0.776217012	0.776217012	0.0018874
489	8.53466	69.13253	0.3423868	0.770744278	0.770744278	0.0018508
490	8.552113	69.5571	0.3442376	0.765444156	0.765444156	0.001814
491	8.569567	69.97324	0.3460516	0.760311908	0.760311908	0.0017772
492	8.58702	70.38093	0.3478288	0.755342984	0.755342984	0.0017403
493	8.604473	70.78016	0.3495691	0.750533015	0.750533015	0.0017033
494	8.621927	71.17091	0.3512725	0.745877803	0.745877803	0.0016663
495	8.63938	71.55317	0.3529388	0.741373319	0.741373319	0.0016292
496	8.656833	71.92691	0.354568	0.737015693	0.737015693	0.0015921
497	8.674286	72.29215	0.3561601	0.73280121	0.73280121	0.001555
498	8.69174	72.64886	0.3577151	0.728726303	0.728726303	0.0015178
499	8.709193	72.99705	0.3592329	0.724787549	0.724787549	0.0014806
500	8.726646	73.33671	0.3607135	0.720981661	0.720981661	0.0014434
501	8.7441	73.66784	0.362157	0.717305487	0.717305487	0.0014063
502	8.761553	73.99044	0.3635633	0.713756001	0.713756001	0.0013691
503	8.779006	74.30451	0.3649323	0.710330303	0.710330303	0.0013319
504	8.796459	74.61006	0.3662643	0.70702561	0.70702561	0.0012948
505	8.813913	74.90708	0.367559	0.703839256	0.703839256	0.0012576
506	8.831366	75.19558	0.3688166	0.700768686	0.700768686	0.0012205
507	8.848819	75.47558	0.3700372	0.697811452	0.697811452	0.0011834
508	8.866273	75.74706	0.3712206	0.69496521	0.69496521	0.0011464
509	8.883726	76.01005	0.372367	0.692227719	0.692227719	0.0011094
510	8.901179	76.26455	0.3734764	0.689596834	0.689596834	0.0010724

511	8.918632	76.51056	0.3745489	0.687070504	0.687070504	0.0010355
512	8.936086	76.74811	0.3755843	0.684646771	0.684646771	0.0009986
513	8.953539	76.97719	0.376583	0.682323767	0.682323767	0.0009618
514	8.970992	77.19782	0.3775447	0.680099708	0.680099708	0.000925
515	8.988446	77.41001	0.3784697	0.677972896	0.677972896	0.0008882
516	9.005899	77.61377	0.3793579	0.675941714	0.675941714	0.0008515
517	9.023352	77.80911	0.3802094	0.674004624	0.66	0.0008149
518	9.040806	77.99604	0.3810243	0.672160168	0.64	0.0007782
519	9.058259	78.17457	0.3818025	0.670406961	0.62	0.0007417
520	9.075712	78.34471	0.3825442	0.668743691	0.6	0.0007052
521	9.093165	78.50648	0.3832493	0.667169122	0.58	0.0006687
522	9.110619	78.65987	0.383918	0.665682083	0.56	0.0006323
523	9.128072	78.80491	0.3845503	0.664281475	0.54	0.0005959
524	9.145525	78.94161	0.3851461	0.662966266	0.52	0.0005595
525	9.162979	79.06996	0.3857057	0.66173549	0.5	0.0005232
526	9.180432	79.18999	0.3862289	0.660588244	0.48	0.000487
527	9.197885	79.3017	0.3867159	0.659523691	0.46	0.0004507
528	9.215338	79.4051	0.3871666	0.658541053	0.44	0.0004145
529	9.232792	79.5002	0.3875811	0.657639618	0.42	0.0003784
530	9.250245	79.587	0.3879595	0.65681873	0.4	0.0003423
531	9.267698	79.66552	0.3883018	0.656077796	0.38	0.0003062
532	9.285152	79.73575	0.3886079	0.65541628	0.36	0.0002701
533	9.302605	79.7977	0.388878	0.654833704	0.34	0.000234
534	9.320058	79.85139	0.389112	0.654329649	0.32	0.000198
535	9.337511	79.8968	0.38931	0.653903752	0.3	0.000162
536	9.354965	79.93396	0.389472	0.653555706	0.28	0.000126
537	9.372418	79.96285	0.3895979	0.653285263	0.26	8.996E-05
538	9.389871	79.98349	0.3896879	0.653092228	0.24	5.397E-05
539	9.407325	79.99587	0.3897419	0.652976462	0.22	1.799E-05
540	9.424778	80	0.3897598	0.652937883	0.2	-1.8E-05
541	9.442231	79.99587	0.3897419	0.176	0.176	-5.4E-05
542	9.459685	79.98349	0.3896879	0.176	0.176	-9E-05
543	9.477138	79.96285	0.3895979	0.176	0.176	-0.000126
544	9.494591	79.93396	0.389472	0.176	0.176	-0.000162
545	9.512044	79.8968	0.38931	0.176	0.176	-0.000198
546	9.529498	79.85139	0.389112	0.176	0.176	-0.000234
547	9.546951	79.7977	0.388878	0.176	0.176	-0.00027
548	9.564404	79.73575	0.3886079	0.176	0.176	-0.000306
549	9.581858	79.66552	0.3883018	0.176	0.176	-0.000342
550	9.599311	79.587	0.3879595	0.176	0.176	-0.000378
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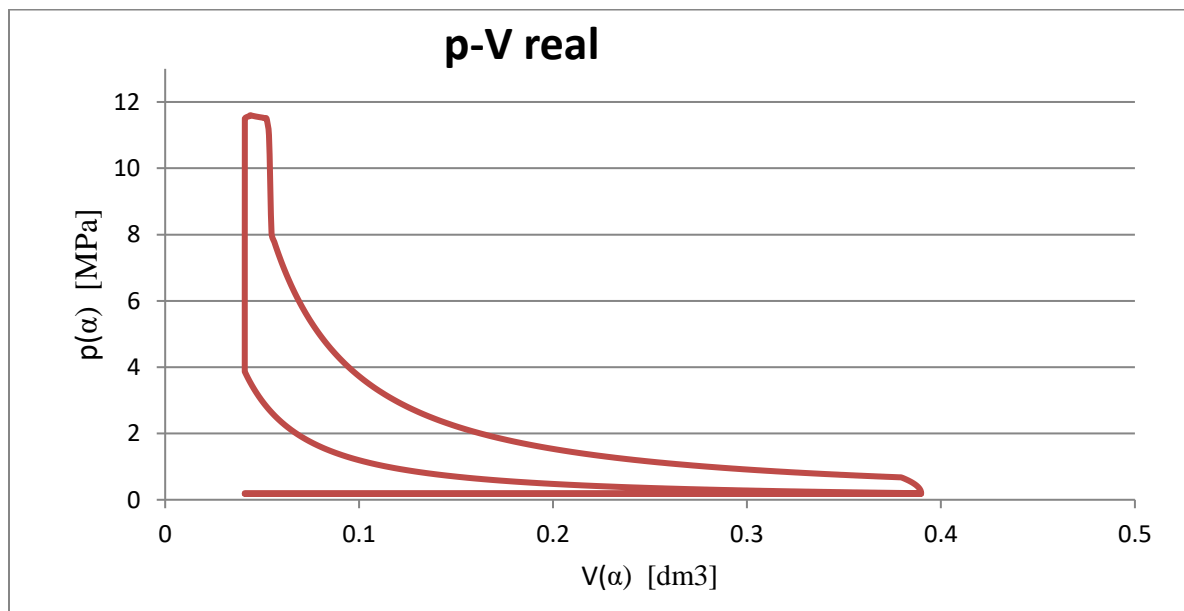
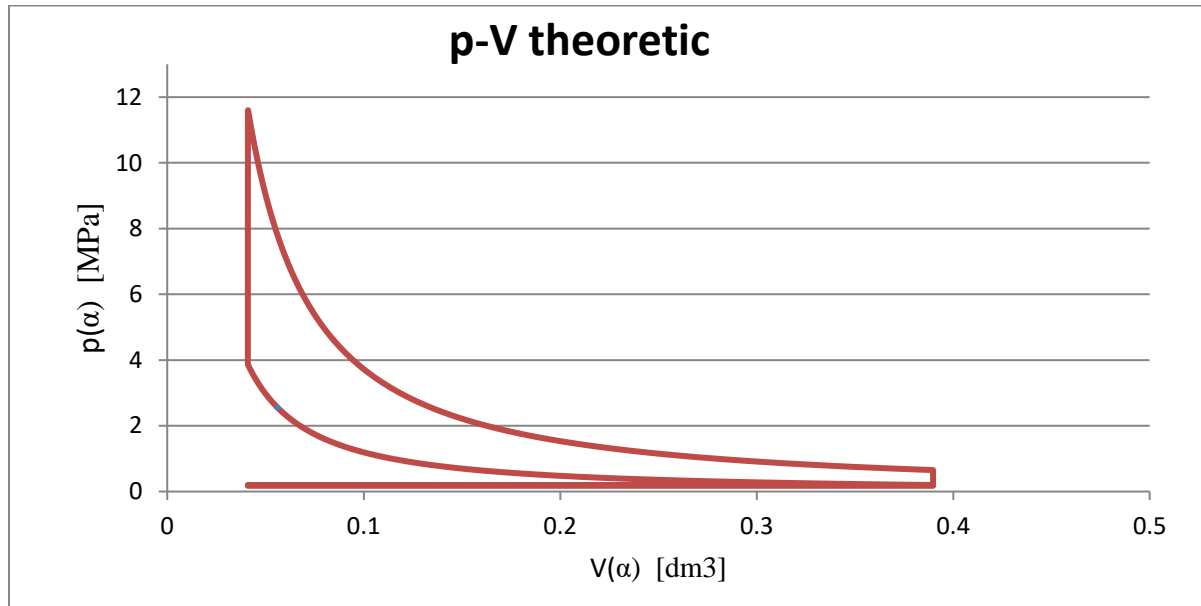
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554	9.669124	79.18999	0.3862289	0.176	0.176	-0.000523
555	9.686577	79.06996	0.3857057	0.176	0.176	-0.00056
556	9.704031	78.94161	0.3851461	0.176	0.176	-0.000596
557	9.721484	78.80491	0.3845503	0.176	0.176	-0.000632
558	9.738937	78.65987	0.383918	0.176	0.176	-0.000669
559	9.756391	78.50648	0.3832493	0.176	0.176	-0.000705
560	9.773844	78.34471	0.3825442	0.176	0.176	-0.000742
561	9.791297	78.17457	0.3818025	0.176	0.176	-0.000778
562	9.80875	77.99604	0.3810243	0.176	0.176	-0.000815
563	9.826204	77.80911	0.3802094	0.176	0.176	-0.000852
564	9.843657	77.61377	0.3793579	0.176	0.176	-0.000888
565	9.86111	77.41001	0.3784697	0.176	0.176	-0.000925
566	9.878564	77.19782	0.3775447	0.176	0.176	-0.000962
567	9.896017	76.97719	0.376583	0.176	0.176	-0.000999
568	9.91347	76.74811	0.3755843	0.176	0.176	-0.001035
569	9.930923	76.51056	0.3745489	0.176	0.176	-0.001072
570	9.948377	76.26455	0.3734764	0.176	0.176	-0.001109
571	9.96583	76.01005	0.372367	0.176	0.176	-0.001146
572	9.983283	75.74706	0.3712206	0.176	0.176	-0.001183
573	10.00074	75.47558	0.3700372	0.176	0.176	-0.001221
574	10.01819	75.19558	0.3688166	0.176	0.176	-0.001258
575	10.03564	74.90708	0.367559	0.176	0.176	-0.001295
576	10.0531	74.61006	0.3662643	0.176	0.176	-0.001332
577	10.07055	74.30451	0.3649323	0.176	0.176	-0.001369
578	10.088	73.99044	0.3635633	0.176	0.176	-0.001406
579	10.10546	73.66784	0.362157	0.176	0.176	-0.001443
580	10.12291	73.33671	0.3607135	0.176	0.176	-0.001481
581	10.14036	72.99705	0.3592329	0.176	0.176	-0.001518
582	10.15782	72.64886	0.3577151	0.176	0.176	-0.001555
583	10.17527	72.29215	0.3561601	0.176	0.176	-0.001592
584	10.19272	71.92691	0.354568	0.176	0.176	-0.001629
585	10.21018	71.55317	0.3529388	0.176	0.176	-0.001666
586	10.22763	71.17091	0.3512725	0.176	0.176	-0.001703
587	10.24508	70.78016	0.3495691	0.176	0.176	-0.00174
588	10.26254	70.38093	0.3478288	0.176	0.176	-0.001777
589	10.27999	69.97324	0.3460516	0.176	0.176	-0.001814
590	10.29744	69.5571	0.3442376	0.176	0.176	-0.001851
591	10.3149	69.13253	0.3423868	0.176	0.176	-0.001887
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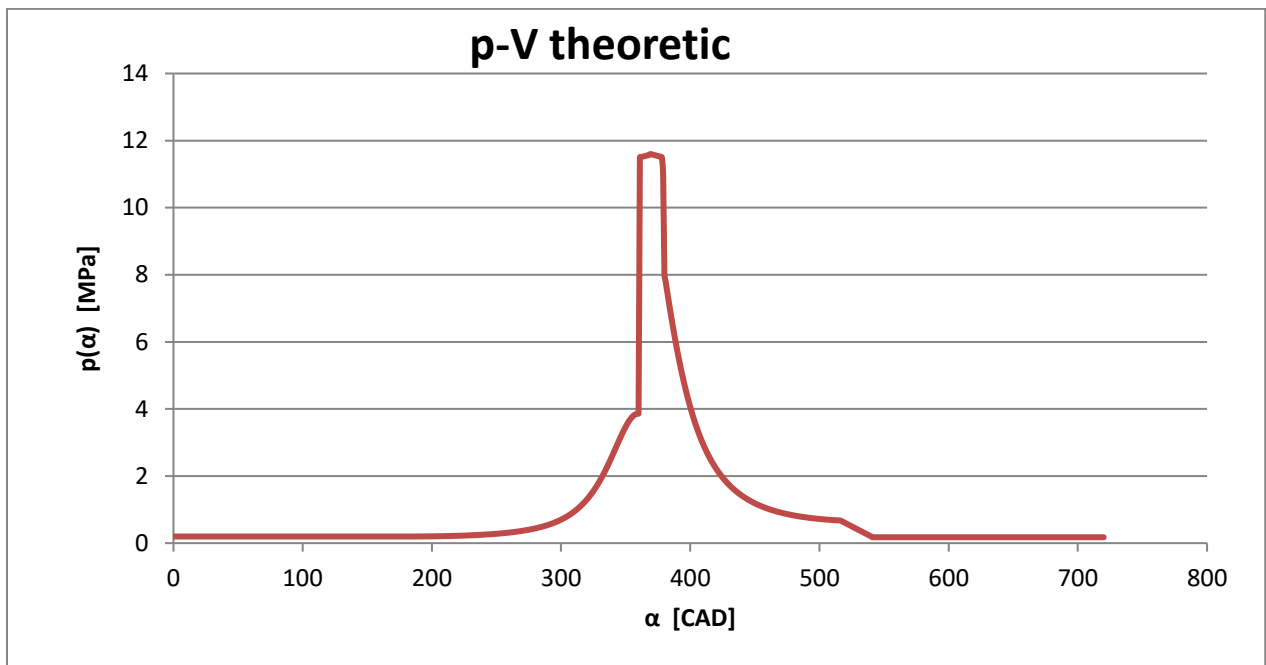
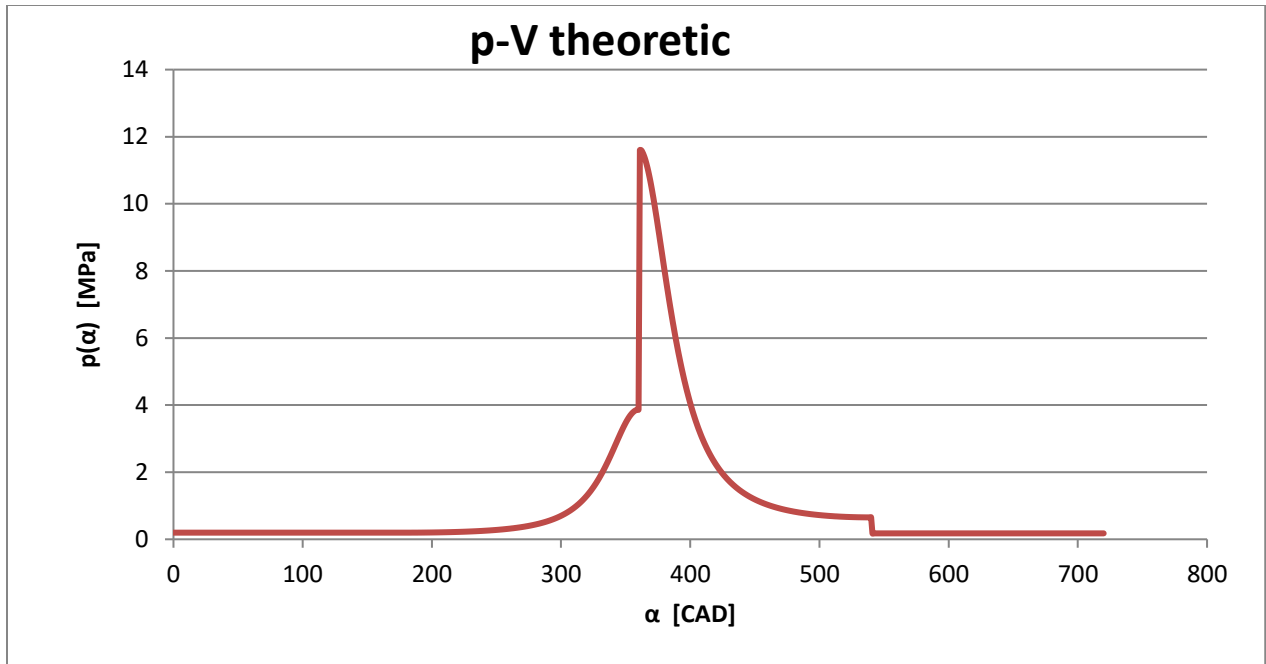
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595	10.38471	67.35048	0.3346186	0.176	0.176	-0.002033
596	10.40216	66.88418	0.3325859	0.176	0.176	-0.002069
597	10.41962	66.40964	0.3305173	0.176	0.176	-0.002104
598	10.43707	65.9269	0.328413	0.176	0.176	-0.00214
599	10.45452	65.436	0.3262731	0.176	0.176	-0.002175
600	10.47198	64.93699	0.3240978	0.176	0.176	-0.00221
601	10.48943	64.42993	0.3218875	0.176	0.176	-0.002245
602	10.50688	63.91488	0.3196423	0.176	0.176	-0.00228
603	10.52434	63.3919	0.3173625	0.176	0.176	-0.002314
604	10.54179	62.86105	0.3150485	0.176	0.176	-0.002348
605	10.55924	62.3224	0.3127004	0.176	0.176	-0.002382
606	10.5767	61.77602	0.3103187	0.176	0.176	-0.002415
607	10.59415	61.22201	0.3079037	0.176	0.176	-0.002448
608	10.6116	60.66044	0.3054557	0.176	0.176	-0.002481
609	10.62906	60.09139	0.3029751	0.176	0.176	-0.002513
610	10.64651	59.51497	0.3004624	0.176	0.176	-0.002544
611	10.66396	58.93127	0.297918	0.176	0.176	-0.002576
612	10.68142	58.3404	0.2953423	0.176	0.176	-0.002607
613	10.69887	57.74246	0.2927358	0.176	0.176	-0.002637
614	10.71632	57.13757	0.290099	0.176	0.176	-0.002667
615	10.73377	56.52586	0.2874324	0.176	0.176	-0.002696
616	10.75123	55.90743	0.2847366	0.176	0.176	-0.002724
617	10.76868	55.28243	0.2820121	0.176	0.176	-0.002753
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619	10.80359	54.01326	0.2764796	0.176	0.176	-0.002807
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621	10.83849	52.71949	0.2708399	0.176	0.176	-0.002858
622	10.85595	52.06377	0.2679815	0.176	0.176	-0.002883
623	10.8734	51.40238	0.2650984	0.176	0.176	-0.002907
624	10.89085	50.73548	0.2621912	0.176	0.176	-0.00293
625	10.90831	50.06326	0.2592609	0.176	0.176	-0.002953
626	10.92576	49.38589	0.2563082	0.176	0.176	-0.002974
627	10.94321	48.70356	0.2533338	0.176	0.176	-0.002995
628	10.96067	48.01647	0.2503387	0.176	0.176	-0.003015
629	10.97812	47.32481	0.2473236	0.176	0.176	-0.003034
630	10.99557	46.62879	0.2442895	0.176	0.176	-0.003052
631	11.01303	45.92862	0.2412374	0.176	0.176	-0.003069
632	11.03048	45.22451	0.2381681	0.176	0.176	-0.003086
633	11.04793	44.51669	0.2350825	0.176	0.176	-0.003101

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636	11.10029	42.37321	0.2257388	0.176	0.176	-0.00314
637	11.11775	41.65283	0.2225986	0.176	0.176	-0.003151
638	11.1352	40.92992	0.2194473	0.176	0.176	-0.003161
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640	11.17011	39.47752	0.213116	0.176	0.176	-0.003178
641	11.18756	38.74854	0.2099383	0.176	0.176	-0.003184
642	11.20501	38.01806	0.206754	0.176	0.176	-0.00319
643	11.22247	37.28635	0.2035644	0.176	0.176	-0.003194
644	11.23992	36.55368	0.2003706	0.176	0.176	-0.003197
645	11.25737	35.82033	0.1971738	0.176	0.176	-0.003199
646	11.27483	35.08659	0.1939753	0.176	0.176	-0.003199
647	11.29228	34.35273	0.1907763	0.176	0.176	-0.003198
648	11.30973	33.61904	0.187578	0.176	0.176	-0.003196
649	11.32719	32.88582	0.1843818	0.176	0.176	-0.003193
650	11.34464	32.15336	0.1811889	0.176	0.176	-0.003188
651	11.36209	31.42196	0.1780006	0.176	0.176	-0.003182
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653	11.397	29.96352	0.171643	0.176	0.176	-0.003167
654	11.41445	29.23709	0.1684764	0.176	0.176	-0.003157
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656	11.44936	27.79135	0.1621742	0.176	0.176	-0.003133
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659	11.50172	25.64516	0.1528186	0.176	0.176	-0.003087
660	11.51917	24.93699	0.1497316	0.176	0.176	-0.003069
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664	11.58899	22.14875	0.1375772	0.176	0.176	-0.002983
665	11.60644	21.46437	0.1345939	0.176	0.176	-0.002959
666	11.62389	20.78568	0.1316354	0.176	0.176	-0.002932
667	11.64135	20.113	0.1287031	0.176	0.176	-0.002905
668	11.6588	19.44664	0.1257983	0.176	0.176	-0.002876
669	11.67625	18.7869	0.1229224	0.176	0.176	-0.002846
670	11.69371	18.13409	0.1200767	0.176	0.176	-0.002814
671	11.71116	17.48852	0.1172625	0.176	0.176	-0.002781
672	11.72861	16.85049	0.1144813	0.176	0.176	-0.002747
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674	11.76352	15.59824	0.1090225	0.176	0.176	-0.002675

675	11.78097	14.98462	0.1063477	0.176	0.176	-0.002637
676	11.79843	14.37973	0.1037108	0.176	0.176	-0.002598
677	11.81588	13.78385	0.1011133	0.176	0.176	-0.002557
678	11.83333	13.19728	0.0985563	0.176	0.176	-0.002515
679	11.85079	12.62029	0.0960412	0.176	0.176	-0.002472
680	11.86824	12.05316	0.093569	0.176	0.176	-0.002428
681	11.88569	11.49617	0.0911409	0.176	0.176	-0.002383
682	11.90315	10.94958	0.0887583	0.176	0.176	-0.002336
683	11.9206	10.41367	0.0864222	0.176	0.176	-0.002288
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685	11.95551	9.374917	0.0818941	0.176	0.176	-0.00219
686	11.97296	8.872579	0.0797043	0.176	0.176	-0.002139
687	11.99041	8.38193	0.0775655	0.176	0.176	-0.002087
688	12.00787	7.903214	0.0754787	0.176	0.176	-0.002034
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690	12.04277	6.982516	0.0714652	0.176	0.176	-0.001925
691	12.06023	6.540988	0.0695405	0.176	0.176	-0.001869
692	12.07768	6.112303	0.0676718	0.176	0.176	-0.001812
693	12.09513	5.696671	0.06586	0.176	0.176	-0.001754
694	12.11259	5.294301	0.064106	0.176	0.176	-0.001695
695	12.13004	4.905391	0.0624107	0.176	0.176	-0.001636
696	12.14749	4.530136	0.0607749	0.176	0.176	-0.001575
697	12.16494	4.168722	0.0591995	0.176	0.176	-0.001514
698	12.1824	3.821331	0.0576851	0.176	0.176	-0.001452
699	12.19985	3.488135	0.0562327	0.176	0.176	-0.00139
700	12.2173	3.169301	0.0548428	0.176	0.176	-0.001327
701	12.23476	2.864989	0.0535163	0.176	0.176	-0.001263
702	12.25221	2.575352	0.0522537	0.176	0.176	-0.001198
703	12.26966	2.300533	0.0510557	0.176	0.176	-0.001133
704	12.28712	2.040672	0.049923	0.176	0.176	-0.001067
705	12.30457	1.795899	0.048856	0.176	0.176	-0.001001
706	12.32202	1.566336	0.0478553	0.176	0.176	-0.000934
707	12.33948	1.352099	0.0469214	0.176	0.176	-0.000867
708	12.35693	1.153296	0.0460547	0.176	0.176	-0.000799
709	12.37438	0.970026	0.0452558	0.176	0.176	-0.000731
710	12.39184	0.802383	0.0445251	0.176	0.176	-0.000662
711	12.40929	0.650449	0.0438628	0.176	0.176	-0.000593
712	12.42674	0.514303	0.0432693	0.176	0.176	-0.000524
713	12.4442	0.394011	0.0427449	0.176	0.176	-0.000455
714	12.46165	0.289636	0.0422899	0.176	0.176	-0.000385
715	12.4791	0.201229	0.0419045	0.176	0.176	-0.000316

716	12.49656	0.128835	0.041589	0.176	0.176	-0.000246
717	12.51401	0.072491	0.0413434	0.176	0.176	-0.000176
718	12.53146	0.032225	0.0411678	0.176	0.176	-0.000105
719	12.54892	0.008057	0.0410625	0.176	0.176	-3.51E-05
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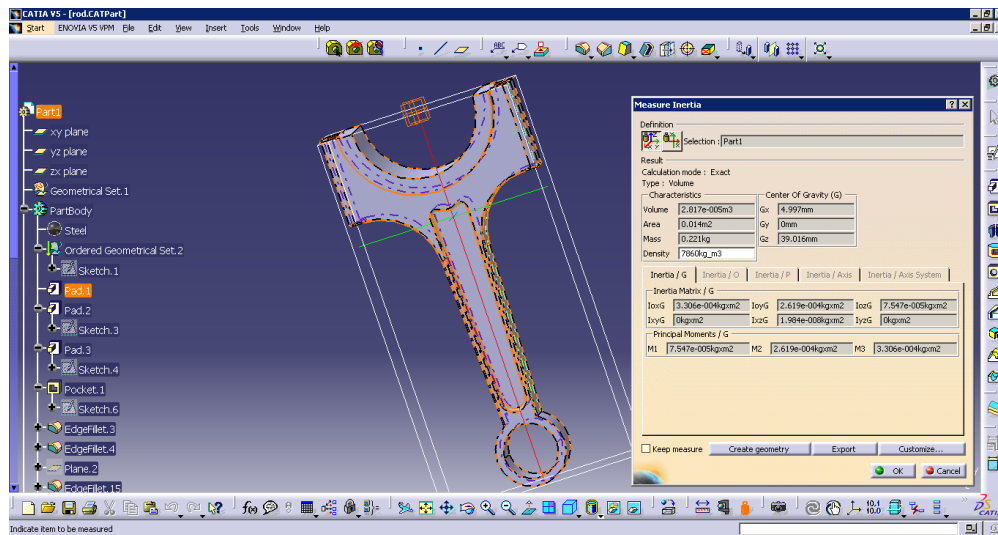
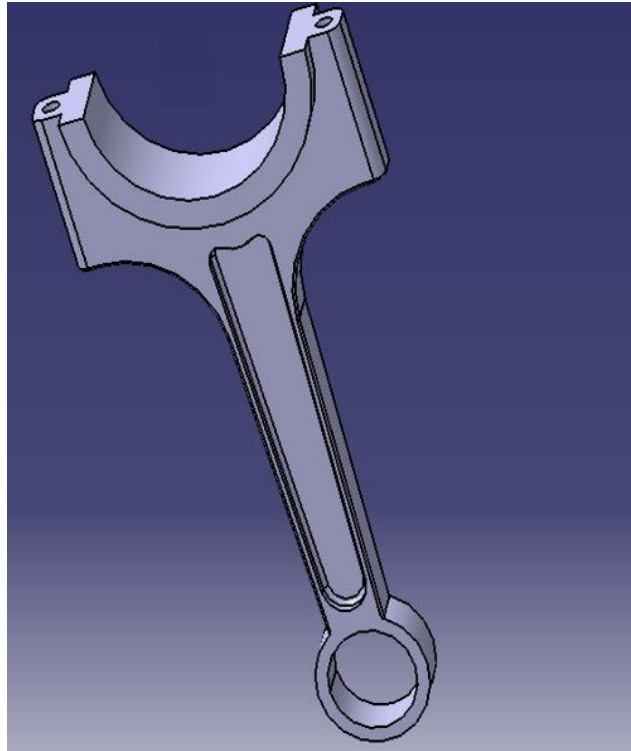


## ***Cad drawings***

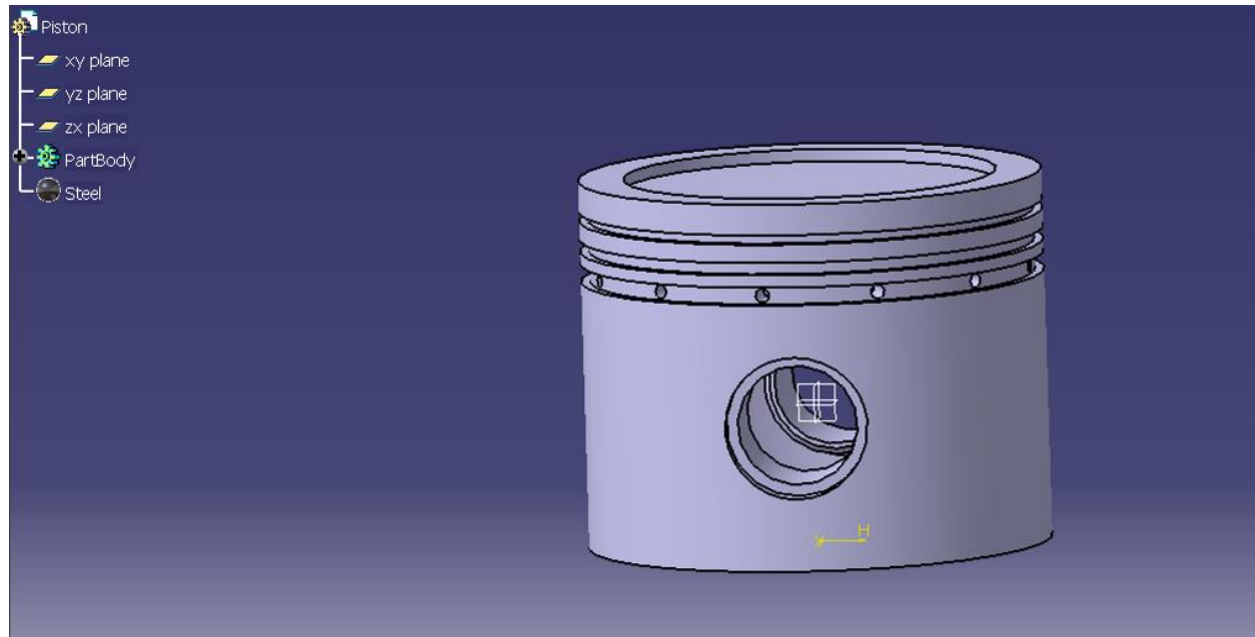
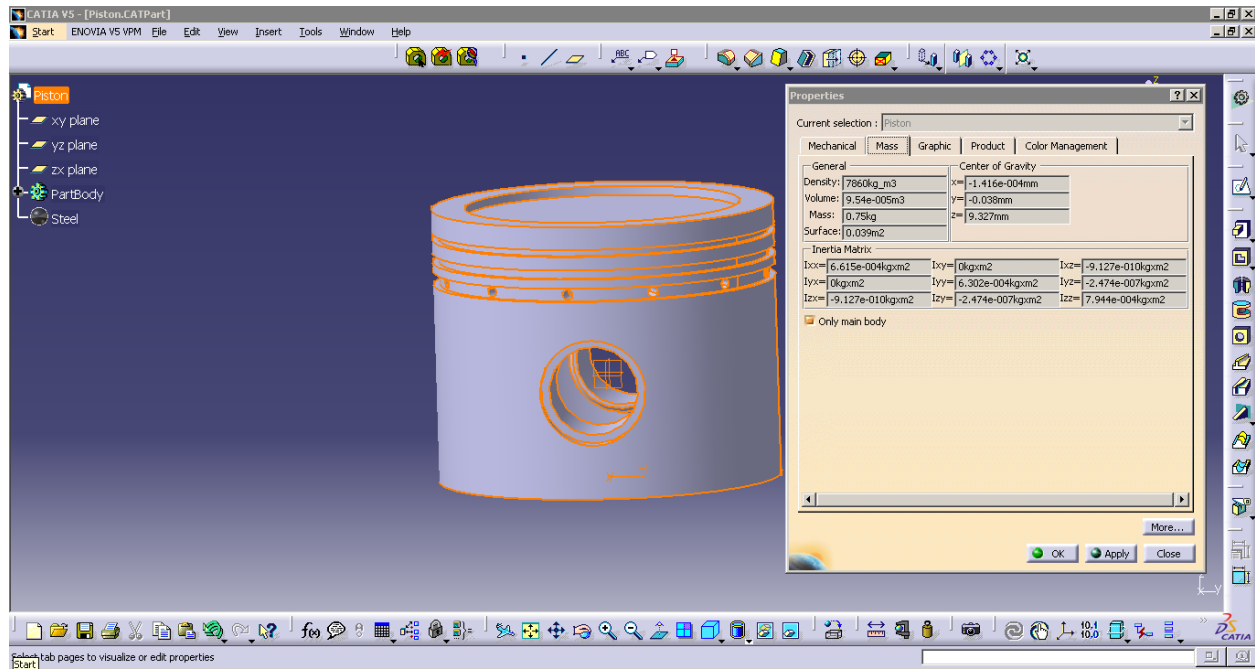
Connecting rod		
d	19.37	mm
d <sub>ib</sub>	19.37	mm
d <sub>e</sub>	24.7936	mm
d <sub>eb</sub>	21.307	mm
l <sub>p</sub>	10	mm
h <sub>p</sub>	3.874	mm
g	1.06535	mm
h <sub>min</sub>	12.3968	mm
h <sub>max</sub>	17.35552	mm
b	6	mm
a	3.6	mm
d <sub>M</sub>	44.7	mm
t	1.341	mm
c	67.497	mm
l <sub>c</sub>	27.714	mm

Piston		
D	74.5	mm
L	59.6	mm
H <sub>c</sub>	40.975	mm
L <sub>m</sub>	37.25	mm
δ	5.96	mm
H <sub>1</sub>	5.066	mm
H	1.5	mm
H <sub>2</sub>	2.98	mm
d	19.37	mm

# Connecting rod



# Piston



# Pin

dimensions	
d	19.37
d1	10.6535
b	25.33
l	62.58

