DEPARTMENT OF MECHANICAL ENGINEERING

KATHMANDU UNIVERSITY

DHULIKHEL, KAVRE

FINAL PROJECT (ENGG III-MECHANICAL)

SUBMITTED BY:

NAME: PRASHANT SHRESTHA

ROLL NO: 49

SUBMITTED TO:

NAME: SAROJ GAUTAM

(LECTURER)

DEPARTMENT OF MECHANICAL ENGINEERING

KATHMANDU UNIVERSITY

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1. SUMMARY

The purpose of this project is to develop an understanding of thermodynamics and to implement it by converting it in the form of program with a view of developing skills and knowledge in this faculty/field. I have prepared my report on a topic related to a small part of a vast topic Thermodynamics. I picked a question related to adiabatic process. Further, I have changed the values of the variables so that the problem is not static. Then, I created a program based on the question. I wrote a program in C language using all the knowledge I have acquired about C. This is a final project and contains all the parts needed to make this project a complete and well prepared. All the solutions, explanation, algorithms, flowcharts, and source code are provided in this report.

2. INTRODUCTION

All the activities in nature involve some interaction between energy and matter, thus, it is hard to imagine an area that does not relate to thermodynamics in some manner. Thermodynamics can be defined as the science of energy. Energy can be viewed as ability to cause changes. Thermodynamics is broadly interpreted to include all aspects of energy and energy transformation including power generation, refrigeration, and relationships among the properties of matter.

Thermodynamics is an axiomatic science which deals with the relation among heat, work and properties of system which are in equilibrium. It describes state and changes in state of physical systems. The analysis of thermal systems is achieved through the application of the governing conservation equations, namely Conservation of Mass, Conservation of Energy (first law of thermodynamics), the second law of thermodynamics and the property relations.

The First law of thermodynamics is simply an expression of the conservation of energy principle, and it asserts that energy is a thermodynamic property. The Second law of thermodynamics asserts that energy has quality as well as quantity, and actual processes occur in the direction of decreasing quality of energy.

Here is some semantics required for the problem to be solved in the project:

Closed system - A closed system consists of a fixed amount of mass, and no mass can cross its boundary. That is, no mass can enter or leave a closed system. But energy, in the form of heat or work, can cross the boundary.

Isolated system - It is a special case of closed system, even energy is not allowed to cross the boundary, that system is called an isolated system.

Open system - In open system or control volume, has mass as well as energy crossing the boundary, called a control surface.

Adiabatic process - It is a thermodynamics process which occurs without heat or mass between the system and surrounding. Unlike isothermal process, adiabatic process transfer energy to the surrounding only as work.

2.1 Objectives

- To do a mathematical problem of thermodynamics
- To develop a program which is capable of giving the desired output on the basis of the values of the variables provided
- To provide different values of the variable to the program and check for its efficiency

3. DISCUSSION

The problem selected for the project is related to thermodynamics. The problem is related to work done on piston by the gas pressure. More information about the problem is provided below.

3.1 Problem

Gas expands in a cylinder according to the relation, $P.V^{1.3}$ = C from an initial state of 0.3 m^3 and 1000 kPa to a final state of 101m kPa. Calculate the work done on the piston by the gas pressure.

3.2 Problem explanation

The problem is related to adiabatic process. Given that the gas expands according to the relation $PV^{1.3} = C$, it is in the form of $PV^{r} = C$ i.e. Adiabatic process. Initial pressure, final pressure and initial volume are provided in the question and final volume is to be calculated using the relation of $P_1V_1^{r} = P_2V_2^{r}$. After the calculation of final volume, work done by gas pressure can be calculated using the formula $(P_1V1 - P_2V_2) / (r - 1)$.

4. SOLUTION

4.1 First Case:

In the first case, I have presented the solution of the actual question (mentioned in 2.1). I have solved the problem just using the process mentioned in 2.2. As I have solved the actual problem in this case, there is no change in the values of the variables. The solution to the problem is presented below.

Given,

Initial Pressure (P_1) = 1000 kPa

Final pressure (P_2) = 101 kPa

Initial Volume (V_1) = 0.3 m^3

Final Volume (V_2) =?

Ratio of specific heats (γ) = 1.3

Now,

Under reversible adiabatic process,

$$P_1V_1^{\gamma} = P_2V_2^{\gamma}$$

or, $$V_2 = \sqrt[r]{\frac{P_1V_1^{\gamma}}{P_2}}$$

or, $$V_2 = \sqrt[1.3]{\frac{1000 \text{ x } (0.3)^{1.3}}{101}}$$

or, V_2 = 1.749959067 m^3

Then,

Work done by the gas pressure (W) = $\frac{P_1V_1 - P_2V_2}{\gamma - 1}$

or, $$W = \frac{1000 \times 0.3 - 101 \times 1.749959067}{1.3 - 1}$$

or, W = 410.85 KJ

Therefore, the work done on the piston by the gas pressure is 410.85 KJ.

4.2 Second Case:

This is one of the cases where I have changed any one of the value and calculated the outcome of the question. In this case, I have changed the value of initial pressure (P_1) from 1000 kPa to 500 KPa. Therefore, the solution to the problem 2.1 after the change in initial pressure is given below.

Given,

Initial Pressure (P_1) = 500 kPa

Final pressure (P_2) = 101 kPa

Initial Volume (V_1) = 0.3 m^3

Final Volume (V_2) = ?

Ratio of specific heats (γ) = 1.3

Now,

Under reversible adiabatic process,

$$P_1V_1^{r} = P_2V_2^{r}$$

$$\text{or,}\quad V_2 = \sqrt[r]{\frac{P_1V_1^{r}}{P_2}}$$

$$\text{or,}\quad V_2 = \sqrt[1.3]{\frac{500 \text{ x } (0.3)^{1.3}}{101}}$$

$$\text{or,}\quad V_2 = 1.026753886 \text{ m}^3$$

Then, Work done by the gas pressure (W) = $\frac{P_1V_1 - P_2V_2}{\gamma - 1}$

$$\text{or,}\quad W = \frac{500 \times 0.3 - 101 \times 1.026753886}{1.3 - 1}$$

$$\text{or,}\quad W = 154.33 \text{ KJ}$$

Therefore, the work done on the piston by the gas pressure is 154.33 KJ.

4.3 Third Case:

In this case, I have changed the initial volume (V_1) from 0.3 to 0.5. The solution to so created problem is given below.

Given,

Initial Pressure (P_1) = 1000 kPa

Final pressure (P_2) = 101 kPa

Initial Volume (V_1) = 0.5 m^3

Final Volume (V_2) = ?

Ratio of specific heats (r) = 1.3

Now,

Under reversible adiabatic process,

$$P_1V_1^r = P_2V_2^r$$

or, $V_2 = \sqrt[r]{\frac{P_1V_1^r}{P_2}}$

or, $V_2 = \sqrt[1.3]{\frac{1000 \text{ x } (0.5)^{1.3}}{101}}$

or, $V_2 = 2.916598445 \text{ m}^3$

Then,

Work done by the gas pressure (W) = $\frac{P_1V_1 - P_2V_2}{r-1}$

or, $W = \frac{1000 \times 0.5 - 101 \times 2.916598445}{1.3 - 1}$

or, W = 684.75 KJ

Therefore, the work done on the piston by the gas pressure is 684.75 KJ.

4.4 Fourth Case:

In this case, I have changed the value of final Pressure (P_2) from 101 KPa to 150 KPa. The solution of the so created is given below.

Given,

Initial Pressure (P_1) = 1000 kPa

Final pressure (P_2) = 150 kPa

Initial Volume (V_1) = 0.3 m^3

Final Volume (V_2) = ?

Ratio of specific heats (γ) = 1.3

Now,

Under reversible adiabatic process,

$$P_1V_1^{\gamma} = P_2V_2^{\gamma}$$

$$\text{or, } V_2 = \sqrt[\gamma]{\frac{P_1V_1^{\gamma}}{P_2}}$$

$$\text{or, } V_2 = \sqrt[1.3]{\frac{1000 \text{ x } (0.3)^{1.3}}{150}}$$

$$\text{or, } V_2 = 1.290913698 \text{ m}^3$$

Then,

$$\text{Work done by the gas pressure (W)} = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$$

$$\text{or, } W = \frac{1000 \times 0.3 - 150 \times 1.290913698}{1.3 - 1}$$

$$\text{or, } W = 354.54 \text{ KJ}$$

Therefore, the work done on the piston by the gas pressure is 354.54 KJ.

5. Algorithm

Here is the actual algorithm of the program. As mentioned on the proposal, then provided algorithm was a tentative algorithm. There was a slight change in the program. Now, the program asks the user whether to change the units or not (if not in standard units). So, the conversion step is added to the program. Algorithm is provided below:

- ### Algorithm

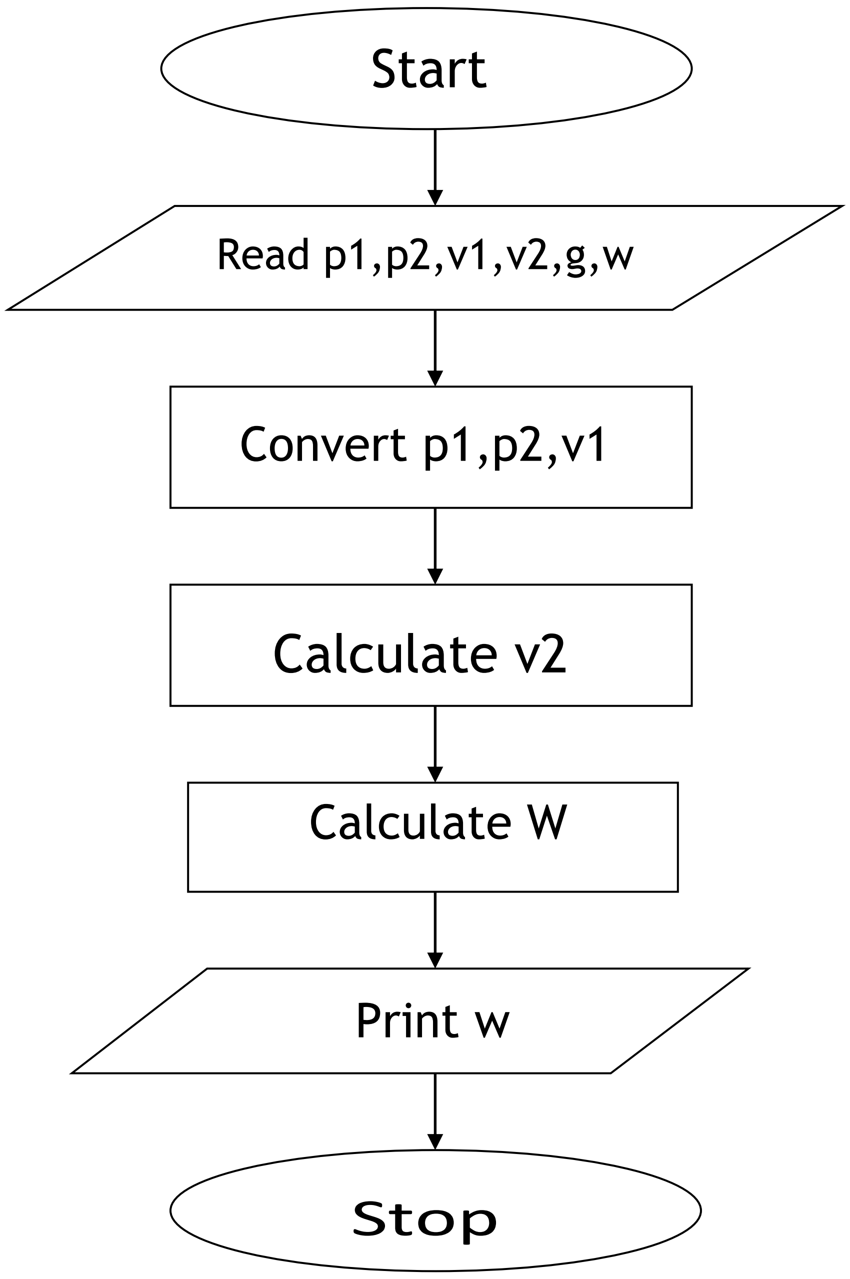
1. Start
2. Declare float p1,p2,v1,v2,g,w
3. Read p1,p2,v1,v2,g
4. Convert p1,p2,v1
5. Store new value of p1,p2,v1
6. Calculate v2
7. Store v2
8. Calculate w
9. Store w
10. Print w
11. End

In the algorithm presented above, variables p1, p2, v1, v2, g represent initial pressure, final pressure, initial volume, final volume and ratio of specific heats. Also the work done by the gas pressure on the piston is represented by w.

6. FLOWCHART

Here is a flowchart based on the algorithm provided above. Just like algorithm there was a slight change in the flowchart from the previous flowchart provided during proposal. Flowchart of the program is provided below:

- **Flowchart**



7. SOURCE CODE

```
#include <stdio.h>

#include <stdlib.h>
```

```
#include <math.h>


float convert_pressure();

float convert_volume();

float calculation();

float p1=0,p2=0,v1=0,v2=0,g=1.3;


int main()

{


  printf("THE UNITS NEEDS TO BE STANDARD UNITS.\nPLEASE CONVERT THE UNITS INTO STANDARD UNITS IF NEEDED.\nNOTE: EVEN THE HIGHER UNITS SHOULD BE CONVERTED.\n");

  printf("\n(PLEASE MAKE SURE THE UNITS OF PRESSURE AND VOLUME ARE IN PASCAL AND CUBIC METRE RESPECTIVELY.)\n");


  unitsconversion:              //Beginning of units conversion loop

     {

         int unitsresponse_1=0;

  printf("\nDO YOU NEED TO CONVERT THE UNITS :\n- PRESS 1 FOR YES\n- PRESS 0 FOR NO\n");

  scanf("%d",&unitsresponse_1);


        if(unitsresponse_1==1)

        {

            int unitsresponse_2=0;
```

```
        printf("\nPRESS THE APPROPRIATE KEY:\n1) CONVERT PRESSURE\n2)
CONVERT VOLUME\n");
        scanf("%d",&unitsresponse_2);

        if(unitsresponse_2==1)
          {
            convert_pressure();
            goto unitsconversion;
          }

        else if(unitsresponse_2==2)
          {
            convert_volume();
            goto unitsconversion;
          }

        else
        {
          printf("INVALID INPUT !!");
          goto unitsconversion;
        }
      }
    } //End of units conversion loop



  //if there is no conversion of units
```

```c
    if(p1==0)
    {
        printf("\nENTER INITIAL PRESSURE : ");
        scanf("%f",&p1);
    }

    if(p2==0)
    {
        printf("\nENTER FINAL PRESSURE : ");
        scanf("%f",&p2);
    }

    if(v1==0)
    {
        printf("\nENTER INITIAL VOLUME : ");
        scanf("%f",&v1);
    }

    //function calculation solves the problem
    calculation();



    return 0;
}
```

```
float convert_pressure(){

   float pressure=0;

   here:
   printf("\n\nEnter the value of pressure only:");
   scanf("%f",&pressure);

   int n;
   printf("\n\nPRESS THE APPROPRIATE KEY : \n");
   printf("1) Atmospheric pressure(atm) to pascal(pa) \n2) Torr(Torr) to
pascal(pa) \n3) Bar(bar) to pascal(pa) \n4) Kilo Pascal(KPa) to pascal(pa) \n5)
Exit\n");
   scanf("%d",&n);

   float a=0;
   if(n==1)
   {
      a=pressure*101325;
      goto last;
   }
   else if(n==2)
   {
     a=pressure*133.322;
      goto last;
   }
```

```
else if(n==3)
{
   a=pressure*100000;
   goto last;
}
else if(n==4)
{
   a=pressure*1000;
   goto last;
}
else if(n==5)
{
   return 0;
}
else
{
   printf("INVALID INPUT !!");
   goto here;
}

int temp=0;
last:
printf("\nSTORE THE VALUE AS :\n");
printf("1)Initial Pressure \n2)Final Pressure \n");
scanf("%d",&temp);
```

```
        if(temp==1)
            p1=a;
        else if(temp==2)
            p2=a;
        else
        {
         printf("\nINVALID INPUT !!!\n");
         goto last;
        }
        return 0;
}

float convert_volume()
{
        float volume=0;

    here:
    printf("\n\nEnter the value of volume only: ");
    scanf("%f",&volume);

    int n;
    printf("\n\nPRESS THE APPROPRIATE KEY : \n");
    printf("1) Barell to cubic metre \n2) Litre to cubic metre \n3) Gallon to
cubic metre \n4) Cubic centimetre to cubic metre \n5) Cubic mililitre to cubic
```

```
metre \n6) Cubic inch to cubic metre \n7) Cubic foot to cubic metre \n8)
Exit\n");
  scanf("%d",&n);

  if(n==1)
  {
    v1=volume*0.15898729493;
    return 0;
  }
  else if(n==2)
  {
    v1=volume*0.001;
    return 0;
  }
  else if(n==3)
  {
    v1=volume*0.00378541;
    return 0;
  }
  else if(n==4)
  {
    v1=volume*0.000001;
    return 0;
  }
  else if(n==5)
  {
```

```
        v1=volume*0.000000001;
        return 0;
    }
    else if(n==6)
    {
        v1=volume/61024;
        return 0;
    }
    else if(n==7)
    {
        v1=volume*0.0283168;
        return 0;
    }
    else if(n==8)
    {
        return 0;
    }
    else
    {
        printf("INVALID INPUT !!");
        goto here;
    }

}
```

```
float calculation()
{
   float a=0;

   a=(p1*pow(v1,g))/p2 ;
   v2=pow(a,1/g);

   float wj=((p1*v1)-(p2*v2))/0.3 ;
   float wkj=wj/1000 ;

   printf("\n\nTHE WORK DONE ON THE PISTON BY THE GAS PRESSURE IS %.2f KJ.\n",wkj);

   return 0;
}
```

8. PROGRAM DESCRIPTION

Program at the very beginning deals with the unit conversion as shown in figure 1. If the units are to be converted, the program offers many options to the user. Pressure can be converted from four different units to standard unit i.e. Pascal as shown in figure 2. Similarly, volume can be converted from seven different units to standard unit i.e. cubic meter as shown in figure 3. In case there is no need of conversion of units, the program asks for the value of required variables like initial pressure, final pressure and initial volume. And after all the values are obtained, program displays the result i.e. work done on the piston by the gas pressure as shown in figure 4.

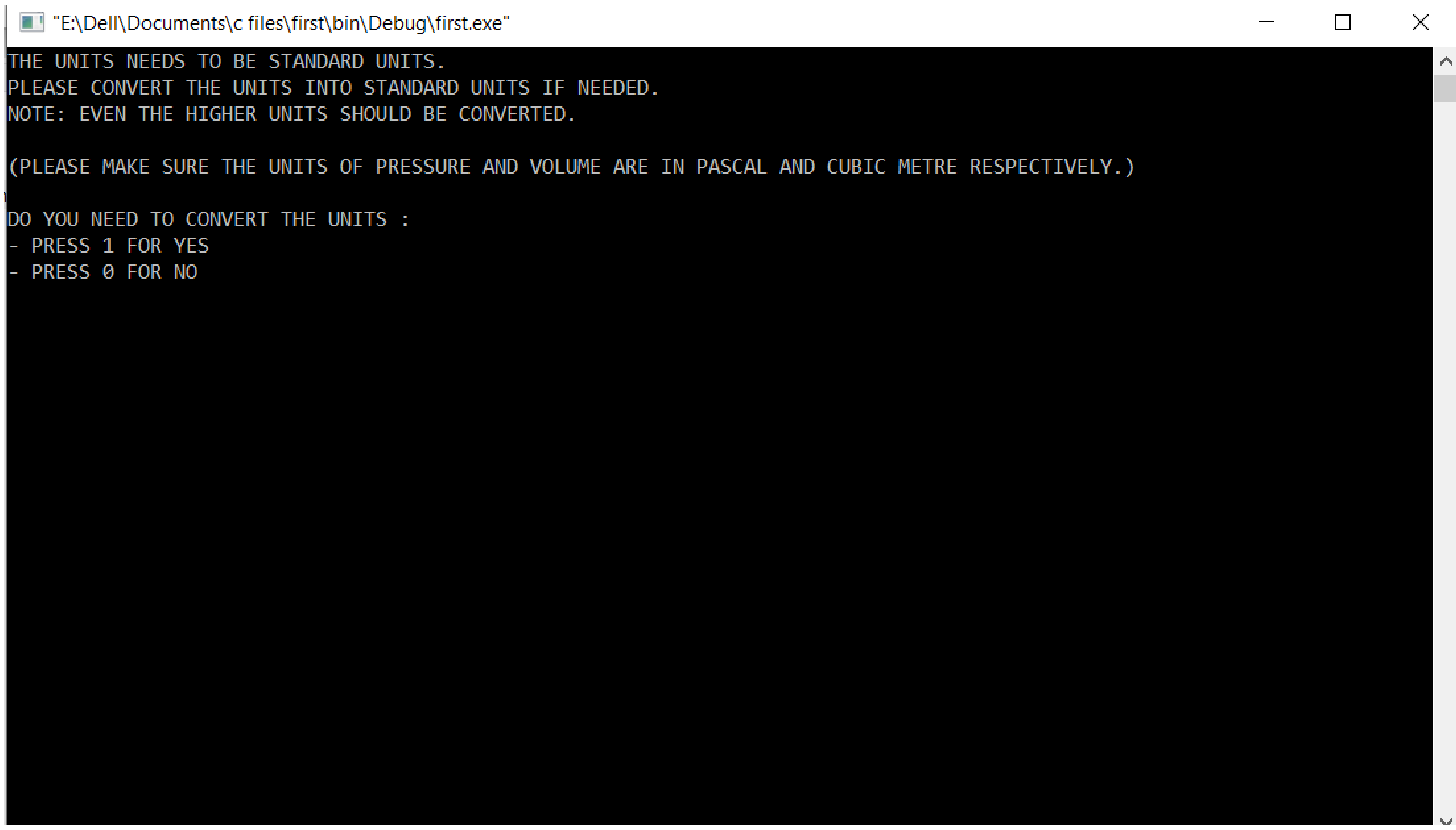


Figure 1

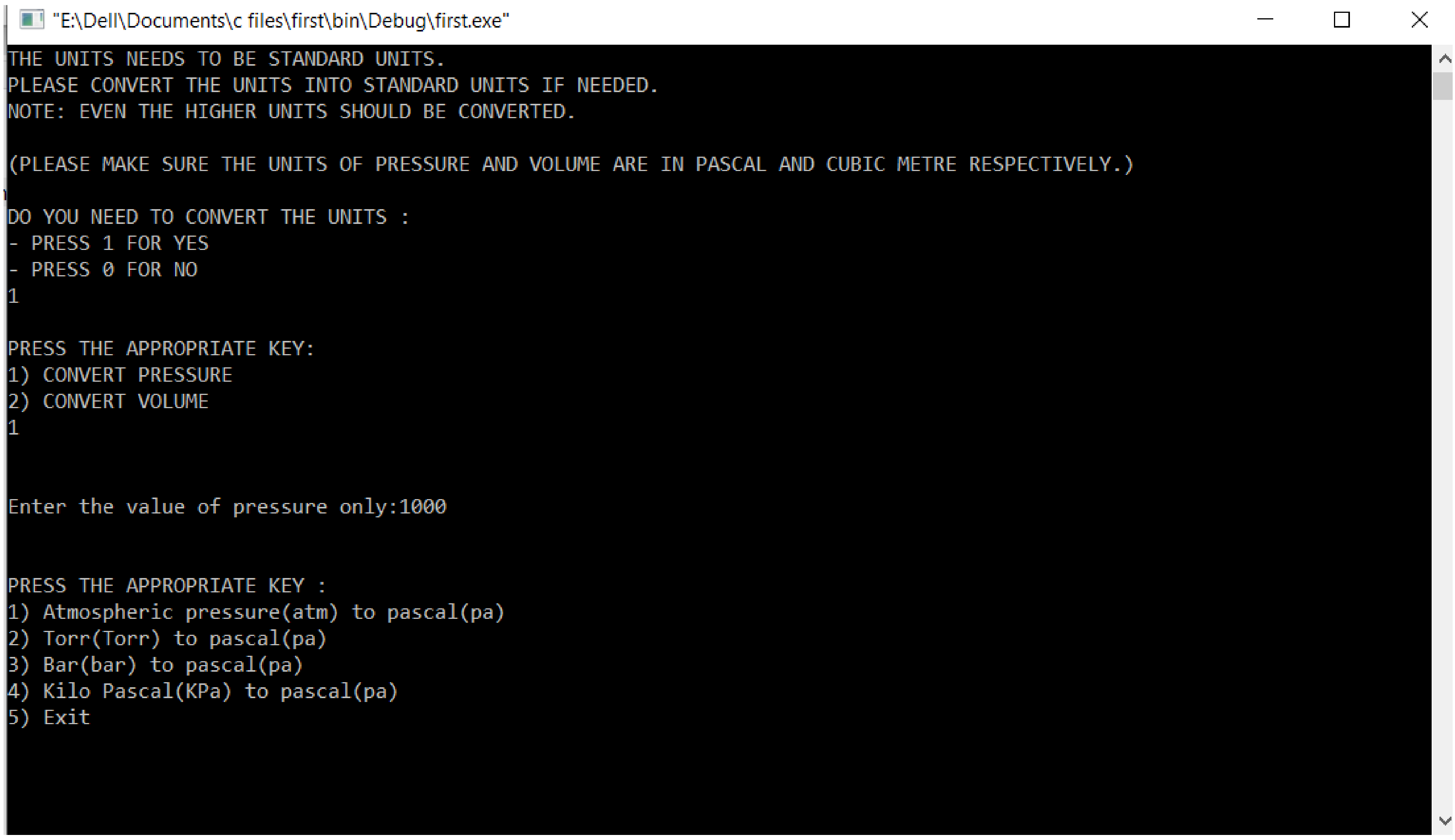


Figure 2

```
"E:\Dell\Documents\c files\first\bin\Debug\first.exe"
DO YOU NEED TO CONVERT THE UNITS :
- PRESS 1 FOR YES
- PRESS 0 FOR NO
1

PRESS THE APPROPRIATE KEY:
1) CONVERT PRESSURE
2) CONVERT VOLUME
2


Enter the value of volume only: 0.3


PRESS THE APPROPRIATE KEY :
1) Barell to cubic metre
2) Litre to cubic metre
3) Gallon to cubic metre
4) Cubic centimetre to cubic metre
5) Cubic mililitre to cubic metre
6) Cubic inch to cubic metre
7) Cubic foot to cubic metre
8) Exit
```

Figure 3

```
"E:\Dell\Documents\c files\first\bin\Debug\first.exe"

Enter the value of pressure only:101


PRESS THE APPROPRIATE KEY :
1) Atmospheric pressure(atm) to pascal(pa)
2) Torr(Torr) to pascal(pa)
3) Bar(bar) to pascal(pa)
4) Kilo Pascal(KPa) to pascal(pa)
5) Exit
4

STORE THE VALUE AS :
1)Initial Pressure
2)Final Pressure
2

DO YOU NEED TO CONVERT THE UNITS :
- PRESS 1 FOR YES
- PRESS 0 FOR NO
0

ENTER INITIAL VOLUME : 0.3


THE WORK DONE ON THE PISTON BY THE GAS PRESSURE IS 410.85 KJ.

Process returned 0 (0x0)   execution time : 16.101 s
Press any key to continue.
```

Figure 4

9. CONCLUSION

The concept of the program and working of the program are all explained above. The idea of the program was to develop understanding and knowledge about ENGG, programming and report writing. Though Thermodynamics is a very vast topic, the selected problem was related to a small part of thermodynamics. Program had simple structure and algorithm. This report doesn't have any reference included as there was no reference taken from any source.

****THE END****