C5 Solutions

1. Convert the following base 10 numbers into 8-bit 2's complement notation
   0, -1, -12

   To Compute 0

   0 = 00000000

   To Compute –1

   Step 1. Convert 1 to binary
   00000001

   Step 2. Flip the bits
   11111110

   Step3. Add 1
   11111111

   Therefore **–1 = 11111111**

   To Compute –12

   Step 1. Convert 12 to binary
   00001100

   Step 2. Flip the bits
   11110011

   Step3. Add 1
   11110100

   Therefore **–12 = 11110100**

2. Perform each of the following additions assuming that the bit strings represent values in 2's complement notation. Identify the cases in which the answer is incorrect because of overflow.

$$\begin{array}{r} 1111 \\ +\ \ 1111 \\ \hline 11110 \end{array}$$

Answer = 11110
Overflow = 0
∴ Answer is correct

$$\begin{array}{r} 01111 \\ +\ \ 10001 \\ \hline 100000 \end{array}$$

Answer = 00000
Overflow = 1
∴ Answer is incorrect

$$\begin{array}{r} 01110 \\ +\ \ 01010 \\ \hline 11000 \end{array}$$

Answer = 11000
Overflow = 0
∴ Answer is correct

3. Write an algorithm to convert a negative decimal number into a binary number in 2's complement form. Assume that the number ranges from +127 to -128

   1. If the number is less than 0
      a. Multiply by –1
      b. Flip the bits by 'number XOR 0xff'
      c. Add 1 to the result

   2. Convert the number into binary

   Hint: You already know how to convert a positive decimal number into binary notation. Think about determining sign and inverting bit positions.

4. Implement your algorithm in Ada95. Turn in an electronic copy of your code listing and a hard copy of your code.

GNAT 3.13p (20000509) Copyright 1992-2000 Free Software Foundation, Inc.

Compiling: c:/docume~2/jk/desktop/16070/codeso~1/decimal_to_binary.adb (source file time stamp: 2003-09-17 11:09:18)

```
with Ada.Text_Io;
use Ada.Text_Io;

with Ada.Integer_Text_Io;
use Ada.Integer_Text_Io;

procedure Decimal_To_Binary is

   -- bit-wise operations are only defined for modular types
   type byte is mod 256;

   Number_To_Convert : integer;
   Place_Holder: Byte;

   Binary_Number : String (1..8);
   Count : Integer :=8;


begin
   -- set the string to all zeroes
   Binary_Number :="00000000";

   -- get the number to be converted
   Put("Please enter an integer :");
   Get(Number_To_Convert);

   -- check if the number is negative. If it is,
   -- convert it into positive
   if Number_To_Convert < 0 then

      Number_To_Convert := -1 * Number_To_Convert;

```

```
    -- convert to modular type
    Place_Holder := Byte'Val(Integer'Pos(Number_To_Convert));

    -- flip the bits
    Place_Holder := Place_Holder xor 2#11111111#;
    -- add 1
    Place_Holder := Place_Holder + 2#1#;
    -- reconvert to integer
    Number_To_Convert := Integer'Val(Byte'Pos(Place_Holder));

  end if;

  -- decimal to binary conversion
  -- fill in the bit pattern from left to right
  loop
    exit when Count = 0;
    -- if the remainder is non-zero, the bit is set to 1
    -- else the bit is 0
    if (Number_To_Convert mod 2) = 1 then
      Binary_Number(Count) :='1';
    else
      Binary_Number(Count) :='0';
    end if;

    Count := Count -1;
    Number_To_Convert := Number_To_Convert/2;

  end loop;

  Put(Binary_Number);

end Decimal_To_Binary;
```

67 lines: No errors

C6

1. How many bits do you need to represent a number in excess-16 format? What is the excess-16 representation of 12?

   $16 = 2^4 = 2^{N-1} \Rightarrow N = 5.$

   Five bits are needed to represent the number in excess-16 format.

   Step 1. Add 16 to the number
   16+12=28

   Step 2. Convert to binary
   12 in excess-16 = 11100

2. Convert 29/8 into binary 8-bit floating-point representation.

   Step1. Set the sign bit to zero since number is positive

   Step2. Convert the number into binary representation
   29/8 = 3 + 5/8
   = 011.101

   Step 3. Normalize the binary representation

   $0.11101 * 2^2$

   Step 4.Convert the exponent into excess-4

   2 = 110

   Step 5. Fill in the mantissa

   Therefore 29/8 = 01101110

3. Sketch the basic von Neumann architecture and describe each component in a few lines.

   The von Neumann architecture describes a computer with four main sections:
   the Arithmetic and Logic Unit (ALU)
   the control unit (CU)
   the memory
   the input and output devices (collectively termed I/O)
   These parts are interconnected by a bundle of wires, a Bus.

The central processing unit (or CPU) is the part of a computer hat interprets and carries out the instructions contained in the software. In most CPUs, this task is divided between a CU that directs program flow and one or more execution units that perform operations on data. Almost always, a collection of Registers is included to hold operands and intermediate results.

The ALU is one of the core components of all CPUs. It is capable of calculating the results of a wide variety of common computations. The most common available operations are the integer arithmetic operations of addition, subtraction, and multiplication, the bitwise logic operations of **and**, **not, or** and **xor**, and various shift operations. The ALU takes as inputs the data to be operated on and a code from the CU indicating which operation to perform, and for output provides the result of the computation. In some designs it may also take as input and output a set of condition codes, which can be used to indicate cases such as carry-in or carry-out, overflow, or other statuses.
The CU the part of a CPU or other device that directs its operation. The outputs of the unit control the activity of the rest of the device.

The memory is a sequence of numbered "cells", each containing a small piece of information. The information may be an **instruction** to tell the computer what to do. The cell may contain **data** that the computer needs to perform the instruction. Any slot **may contain either**, and indeed what is at one time data might be instructions later. In general, memory can be rewritten over millions of times - it is a scratchpad rather than a stone tablet.
The size of each cell, and the number of cells, varies greatly from computer to computer, and the technologies used to implement memory have varied greatly - from electromechanical relays, to mercury-filled tubes in which acoustic pulses were formed, to matrices of permanent magnets, to individual transistors, to integrated circuits with millions of capacitors on a single chip.

The bus is a bundle of wires that interconnect all the different parts of the computer.

4. Write an assembly language program (using the language described in the machine language handout) to add two positive numbers. Assume that the numbers are present in memory locations FEh and FFh. Turn in both a hard copy and an electronic copy of your code.

```
; Program to Add two positive numbers stored in FEh and FFh
; Programmer : Joe B
; Date Last Modified: September 15th 2003

load r1, [FEh] ; load number in FEh
load r2, [FFh] ;load the number in FFh
addi r3, r1,r2;perform the addition operation
store r3,[F0h]; store the result in F0h
halt; stop the program
```

C7

1. Write an algorithm to implement the subtraction operation for two positive integers in assembly language.

    1. Let the numbers be A, B and the operation be A-B
    2. Convert A into binary
    3. Convert B into binary
    4. Compute 2's complement of B
        i. Invert the bits in B using B xor 11111111
        ii. Add 1 to B
    5. Add A and the 2's complement of B.

2. Implement your algorithm in the assembly language describe in the machine language handout. Test your implementation using the SimpleSim simulator.

```
; Program name      : Subtraction using add only
;Programmer         : Joe B
;Last Modified      : Sep 16 2003

      load   R1,1          ;1 added for computing 2's complement
      load   R2,FFh        ;mask for flipping the bits
      load   R3,first_number;
      load   R4, second_number;
      xor    R5, R4,R2     ; flip the 0's and 1's in the second number
      addi   R5,R5,R1      ; add 1 to the flipped bits to get the 2's complement
      addi   R5,R5,R3      ; add the numbers to obtain A - B
      halt

      first_number:     db 8   ;A in A-B
      second_number:    db 5   ;B in A-B
```

A)

LEG	Q	W	
1 - 2	−	−	(ISOTHERMAL SO $C_v\Delta T=0$, Q = W)
2 - 3	+	0	(CONST. V HEATING)
3 - 4	0	+	(ADIABATIC EXPANSION)
4 - 1	−	−	(CONST. P COOLING)

B) LEG 1-2

$q = \omega \quad \omega = RT\ln\left(\frac{V_2}{V_1}\right)$

$T_1 = 300K, \ p_1 = 100\,kPa \Rightarrow V_1 = \frac{RT_1}{P_1} = 0.861\ m^3/kg$

$\frac{P_2}{P_1} = 10 \ \therefore\ P_2 = 1000\,kPa \quad T_2 = 300K$ (isothermal

$\therefore V_2 = \frac{RT_2}{P_2} = 0.0861$

$$\boxed{\begin{array}{l} \omega = -198\ kJ/kg \quad q = -198\ kJ/kg \\ \Delta u = C_v\Delta T = 0, \quad \Delta h = C_p\Delta T = 0 \end{array}}$$

LEG 2-3

$\boxed{W = 0}$ (CONST. VOLUME) $\therefore \Delta u = C_v\Delta T = q$

$T_3 = 1500 \quad T_2 = 300 \quad \therefore \Delta u = 716.5(1200) = \boxed{859.8\ kJ/kg}$

$\Delta h = 1003.5(1200) = \boxed{1204.2\ kJ/kg}$

$\boxed{q = 859.8\ kJ/kg}$

$T_3 = 1500, \ V_3 = 0.0861$

$\therefore P_3 = RT_3/V_3 = 5MPa$

LEG 3-4

$pV^\gamma = \text{CONST.}$

$q = 0$ so $\omega = -C_v(T_4 - T_3)$

$P_3V_3^\gamma = P_4V_4^\gamma \quad P_4 = P_1 = 100kPa \quad P_3 = 5MPa$

$V_3 = 0.0861 \ \therefore V_4 = 1.41\ m^3/kg$

$\therefore\ T_4 = \frac{P_4 V_4}{R} = 491\ \text{K}$

SO $\boxed{q = 0}$ $\quad \boxed{w = -76.5\,(491 - 1500) = 722.7\ \text{kJ/kg}}$

$\boxed{\Delta u = -722.7\ \text{kJ/kg}}$ $\quad \boxed{\Delta h = C_p (T_4 - T_3) = -1013\ \text{kJ/kg}}$

LEG 4-1

P = CONST. $\quad dh = \delta q + v\,\cancel{dp}^{\,0} \quad C_p (T_1 - T_4) = \Delta h = q$

$\boxed{q = \Delta h = 1003.5\,(300 - 491) = -191.7\ \text{kJ/kg}}$ $\quad \boxed{\Delta u = C_v (T_1 - T_4) = -137\ \text{kJ/kg}}$

$\Delta u = q - w \quad \therefore \boxed{w = q - \Delta u = -54.8\ \text{kJ/kg}}$

C) $W_{cycle} = W_{1\text{-}2} + W_{2\text{-}3} + W_{3\text{-}4} + W_{41}$

$= -198 + 0 + 722.7 - 54.8 = 469.9\ \text{kJ/kg}$

D) $\eta = \frac{W_{cycle}}{q_{IN}} = \frac{W_{cycle}}{859.8\ \text{kJ/kg}} = 0.547$

E) IN REVERSE, WORK CYCLE = -469.9 kJ/kg

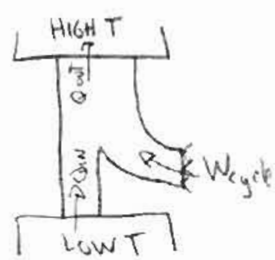
AND ALL SIGNS ON HEAT REVERSED. SO HEAT

FLOWS INTO SYSTEM (FROM FOOD SAY) ARE

DURING LEGS ②-① & ①-④ = 198 kJ/kg + 191.7 kJ/kg

= 389.7 kJ/kg

$\boxed{\text{SO 0.83 J COULD BE REMOVED FOR EACH J OF WORK INPUT.}}$



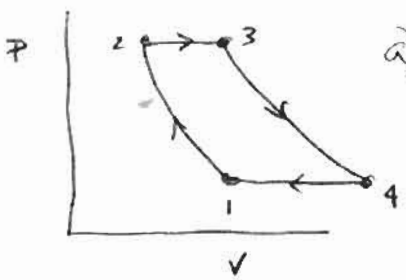
MY DATA WERE OBTAINED 9/16/03 16:50 hrs.

AMBIENT AIR TEMP = 75°F = 297 K
ATMOSPHERIC PRESSURE (ASSUMED) = 1 atm = 101.3 kPa

COMPRESSOR DELIVERY PRESSURE = 200 PSIG = 214.77 PSIA

GAGE (relative to atmospheric) ABSOLUTE

SO PRESSURE RATIO = $\frac{214.77}{14.77} = 14.54$



a) ① $\boxed{p_1 = 101.3\ kPa,\ T_1 = 297K}$

② $\boxed{P_2 = 14.54\,(101.3) = 1473\ kPa}$

$\underbrace{\left(\frac{P_2}{P_1}\right)^{\gamma-1/\gamma}}_{q\text{-s adiab.}} = \frac{T_2}{T_1} = 2.149 \therefore \boxed{T_2 = 638K}$

③ constant pressure heating

$\therefore \boxed{P_3 = 1473\ kPa,\ T_3 = 1400K \text{ (Given)}}$

④ q-s adiabatic expansion by $\frac{P_3}{P_4} = 14.54$

$\therefore \boxed{P_4 = 101.3\ kPa}$

$\left(\frac{P_4}{P_3}\right)^{\gamma-1/\gamma} = \frac{T_4}{T_3} = 0.465 \therefore \boxed{T_4 = 652\ K}$

b) THERMAL EFFICIENCY

$$\eta_{TH} = 1 - \frac{T_1}{T_2} = 1 - \frac{297}{638} = \boxed{0.534}$$

$$W = C_p\,(T_3 - T_2 + T_1 - T_4) = 1003.5\,(1400 - 638 + 297 - 652) = \boxed{408\ kJ/kg}$$

c) T_2 FIXED. COLD DAY $T_1 = 273K$

HOT DAY $T_1 = 303K$

$$\boxed{\eta_{COLD} = 1 - \frac{273}{638} = 0.57 \qquad \eta_{HOT} = 1 - \frac{303}{638} = 0.525}$$

d) TOTAL GAS ENERGY FLOW = 66×10^3 BTU/s = 69.63 MJ/s

= 69.63 MW

ACTIVE LOAD = 20 MW

$$\boxed{\eta = \frac{20}{69.63} = \frac{W_{cycle}}{Q_{IN}} = 0.287}$$

A VARIETY OF NON-IDEAL PROCESSES CAUSE THE EFFICIENCY TO BE SIGNIFICANTLY LESS THAN THE VALUE OBTAINED FOR THE IDEAL CYCLE.

e) FOR PRESSURE RATIO OF 14.54, CALCULATED $\frac{T_2}{T_1} = 2.149$

SO $\boxed{T_2 = 638\text{ K. (IDEAL)}}$

MEASURED T_2 (COMPR DISCHARGE TEMP) = 730 °F

* HIGHER THAN IDEAL Q-S, ADIAB PROCESS $\qquad T_{2_{MEAS.}} = 661\text{ K}$

BUT NOTE THERE IS ALSO SOME COOLING BETWEEN THE AMBIENT ($T_{atm} = 75°F$) AND THE COMPRESSOR INLET (COMP INLET TEMP = 62°F) WHICH WAS NOT ACCOUNTED FOR. IF YOU ACCOUNT FOR THIS OUR Q-S, ADIABATIC MODEL IS EVEN WORSE (i.e. SHOWS A SMALLER ΔT THAN IN REAL DEVICE

a) $P_1 = 1\times10^6\,Pa$, $T_1 = 200K$, $C_1 = 50\frac{m}{s}$ $\dot{m} = 100\,kg/s$

$P_2 = 5\times10^6\,Pa$ via A q-s ADIAB. PROCESS $\therefore\ pv^\gamma = \text{CONST.}$

$C_2 = 50\frac{m}{s}$ $\therefore q = 0$

$$p_1 v_1 = RT_1 \implies v_1 = 0.052\ \frac{m^3}{kg} \qquad (R = 260\ J/kg\text{-}K)$$

$$p_1 v_1^\gamma = p_2 v_2^\gamma,\quad \gamma = \frac{c_p}{c_v} = 1.1 \implies v_2 = 0.012\frac{m^3}{kg}$$

SFEE
$$\cancel{q}^{\,0} - w_s = h_2 - h_1 + \frac{c_2^2}{2} - \frac{c_1^2}{2}$$

OR
$$\cancel{q}^{\,0} - w = u_2 - u_1 + \frac{c_2^2}{2} - \frac{c_1^2}{2}$$

$$w_f = R(T_2 - T_1) = w - w_s$$

SO

$$w = -\left[c_v(T_2 - T_1) + \frac{c_2^2}{2} - \frac{c_1^2}{2}\right], \qquad \frac{P_2 v_2}{R} = T_2 = 230.8K$$

$$\boxed{\begin{array}{l} w = -78.2\ \frac{kJ}{kg} \\ \text{OR} \\ \dot{W} = \dot{m}\,w = -7.8\ MW \end{array}}$$

$$\boxed{\begin{array}{l} w_f = 260\,(230.8 - 200) = 8\ \frac{kJ}{kg} \\ \text{OR} \\ \dot{W}_f = \dot{m}\,w_f = 0.8\ MW \end{array}}$$

$$w_s = -\left[c_p(T_2 - T_1) + \frac{c_2^2}{2} - \frac{c_1^2}{2}\right] = w - w_f$$

$$\boxed{w_s = -86.2\ \frac{kJ}{kg} \quad \text{OR} \quad \dot{W}_s = -8.62\ MW}$$

b) $C_2 = 50\,m/s$, $T_2 = 230.8\,K$, $p_2 = 5\times10^6\,Pa$

$C_3 = 100\,m/s$, $T_3 = ?$, $p_3 = 5\times10^6\,Pa$ $\quad q_{in} = 1300\,kJ/kg$

$$q - \cancel{W_s}^{\,0} = C_p(T_3 - T_2) + \frac{C_3^2}{2} - \frac{C_2^2}{2}$$

(NO SHAFT WORK BUT CAN STILL BE FLOW WORK)

$$1300\times10^3 = 2800(T_3 - 230.8) + \frac{100^2}{2} - \frac{50^2}{2}$$

$$T_3 = 693.7\,, \qquad v_3 = \frac{RT_3}{P_3} = \frac{260\,(693.7)}{5\times10^6} = 0.036\,\frac{m^3}{kg}$$

$\boxed{W_s = 0}$ $\qquad W_f = R(T_3 - T_2)$

$$\boxed{W_f = 260(693.7 - 230.8) = 120\,\frac{kJ}{kg} \text{ or } \dot{W}_f = 1.2\,MW}$$

c) $\boxed{W_{s_{TURBINE}} = -W_{s_{PUMP}} = 86.2\,\frac{kJ}{kg}}$ or $\boxed{\dot{W}_s = 8.6\,MW}$

$$\cancel{q}^{\,0} - W_s = C_p(T_4 - T_3) + \frac{C_4^2}{2} - \frac{C_3^2}{2}$$

$$-86.2^{\times10^3} = 2800(T_4 - 693.7) + \frac{120^2}{2} - \frac{100^2}{2}$$

$$T_4 = 662\,K$$

$$W_f = R(T_4 - T_3) = 260(662 - 693.7) = -8.2\,kJ/kg$$

$$\boxed{W_f = -8.2\,\frac{kJ}{kg} \quad \text{or} \quad \dot{W}_f = -0.82\,MW}$$

a) $p_c = 125\,atm = p_{Tc}$ ($c_c \approx 0$ IN COMBUSTOR)

$T_c = 3000K = T_{Tc}$ ($c_c \approx 0$ IN COMBUSTOR)

$$\cancel{q}^{0} - \cancel{w_s}^{0} = \left(c_pT_e + \frac{c_e^2}{2}\right) - \left(c_pT_c + \frac{c_c^2}{2}\right)$$

$$c_pT_c + \cancel{\frac{c_c^2}{2}}^{0} = c_pT_e + \frac{c_e^2}{2} \qquad \text{ALSO } \left(\frac{p_e}{p_c}\right)^{\frac{\gamma-1}{\gamma}} = \frac{T_e}{T_c} \text{ SINCE}$$

Q-S, ADIABATIC

$$\Rightarrow \quad c_e = \sqrt{2c_pT_c\left[1 - \left(\frac{p_e}{p_c}\right)^{\frac{\gamma-1}{\gamma}}\right]}$$

$$= \sqrt{2(1500)(3000)\left[1 - \left(\frac{1}{125}\right)^{\frac{\gamma-1}{\gamma}}\right]} \qquad \gamma = 1.2$$

$$\boxed{c_{e_{atm}} = 2230\,\frac{m}{s}}$$

b) IN SPACE $\frac{p_e}{p_c} \rightarrow 0$

$$\boxed{c_{e_{space}} = 3000\,\frac{m}{s}}$$

$$c_pT_e + \frac{c_e^2}{2} = c_pT_{Tc}$$

$$1500(T_e) + \frac{2230^2}{2} = 1500(3000)$$

$$\boxed{T_{e_{atm}} = 1342K} \qquad a = \sqrt{\gamma R T_{e_{atm}}} = 634.5\,m/s$$

$$\boxed{M_{atm} = \frac{c_e}{a} = 3.5}$$

b) IN SPACE

$$\boxed{\begin{array}{l} c_e = 3000\,m/s \\ T_e \rightarrow 0\,, \quad M_e \rightarrow \infty \end{array}}$$

c) $\cancel{q}^{\,0} - \cancel{w_s}^{\,0} = h_{T_e} - h_{T_c}$

IF h_{T_c} REDUCED 20% THEN h_{T_e} REDUCED 20%

$\therefore \quad (C_p T_{T_c})(0.8) = C_p T_e + \frac{C_e^2}{2}$

$$\therefore \quad C_e = \sqrt{2 C_p T_{T_c} (0.8) \left[1 - \left(\frac{P_e}{P_c}\right)^{\gamma-1/\gamma}\right]}$$

$$C_{e_{atm}} = \sqrt{2(1500)(3000)(0.8)\left[1 - \left(\frac{1}{125}\right)^{\frac{1.2-1}{1.2}}\right]}$$

$$\boxed{C_{e\,atm} = 1995 \text{ m/s}}$$

$C_{e\,space} \Rightarrow P_e/P_c \to 0$

$$C_{e\,space} = \sqrt{2(1500)(3000)(0.8)[1]}$$

$$\boxed{C_{e\,space} = 2683 \text{ m/s}}$$