Indicate the size of each of the following registers and explain what each is used for:

Program Counter

Instruction Register

R3 Register

X Register

Consider the following .lst file on the back of this page:
(a) How many bytes of memory does the program occupy?

(b) Identify the items in each column below and explain what they represent.

```
Col1   Col2              Col3  Col4          Col5
00002c ef00              ldi   temp,0xf0     ; Enable pull-up resistors on PORTC4-7
```

```
AVRASM ver. 2.1.12  C:\Atmel\Projects\lab0.asm Wed Dec 12 10:42:08 2007

C:\Atmel\Projects\lab0.asm(21): Including file 'c:\Atmel\AVRTools\AvrAssembler2\

                        .list

                        .def temp = r16   ; Use R16 as a temp register

                        .cseg             ; Begin code segment
                        .org 0
000000 c029             rjmp init         ; Initialize restart vector

                        .org 0x2a

                init:
00002a e00f             ldi  temp,0x0f    ; Set keypad cols as output, rows as i
00002b bb04             out  DDRC,temp
00002c ef00             ldi  temp,0xf0    ; Enable pull-up resistors on PORTC4-7
00002d bb05             out  PORTC,temp
00002e ef0f             ldi  temp,0xff    ; Configure PORTB as an output port
00002f bb07             out  DDRB,temp

                main:
000030 b303             in   temp,PINC    ; Read rows of keypad from PORTC
000031 bb08             out  PORTB,temp   ; Display results on LEDs 5-8
000032 cffd             rjmp main         ; Repeat main

[snip]

ATmega32 memory use summary [bytes]:
Segment   Begin    End      Code   Data   Used    Size   Use%
---------------------------------------------------------------
[.cseg] 0x000000 0x000066     20      0     20   32768   0.1%
[.dseg] 0x000060 0x000060      0      0      0    2048   0.0%
[.eseg] 0x000000 0x000000      0      0      0    1024   0.0%

Assembly complete, 0 errors, 0 warnings
```

Suppose that a subroutine starting at address delay (which does nothing for 1 second) already exists. Write your own subroutine, begininng at address blink, that causes the LEDs connected to PORTB all turn on for 1 second and then turn off for 1 second. Once this is done, the subroutine should return.
You may assume that the stack has already been initialized.

(a) What I/O port is used by the Analog to Digital Converter?

(b) What do the **MUX4:0** bits of the **ADMUX** port do?

(c) How many bits are used to store the result of the ADC?

As best as you can, describe the various modes of operation available on the ATmega32's analog to digital subsystem.

Show the correct values for each of the following registers (0, 1 or X (for don't care)) such that the Timer/Counter1 subsystem is configured to interrupt whenever a rising edge is encountered on the **ICR1** pin. on the ATmega32's analog to digital subsystem.

Bit	7	6	5	4	3	2	1	0	
	TCNT1[15:8]								TCNT1H
	TCNT1[7:0]								TCNT1L
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Bit	7	6	5	4	3	2	1	0	
	ICR1[15:8]								ICR1H
	ICR1[7:0]								ICR1L
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Bit	7	6	5	4	3	2	1	0	
	OCIE2	TOIE2	TICIE1	OCIE1A	OCIE1B	TOIE1	OCIE0	TOIE0	TIMSK
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Bit	7	6	5	4	3	2	1	0	
	OCF2	TOV2	ICF1	OCF1A	OCF1B	TOV1	OCF0	TOV0	TIFR
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Bit	7	6	5	4	3	2	1	0	
	COM1A1	COM1A0	COM1B1	COM1B0	FOC1A	FOC1B	WGM11	WGM10	TCCR1A
Read/Write	R/W	R/W	R/W	R/W	W	W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Bit	7	6	5	4	3	2	1	0	
	ICNC1	ICES1	–	WGM13	WGM12	CS12	CS11	CS10	TCCR1B
Read/Write	R/W	R/W	R	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Write the read_ee subroutine that will read the byte stored in EEPROM at data and return it in R24.

```
; ...
.eseg
.org 0x111
data:
      .db 17

.cseg
; ...

read_ee:
```