[**Closed book/notes/calculator**] Show all of your work clearly in the space provided. Be sure to **read each problem carefully**. Note that the exam is double sided.

1. (10 points) The ATmega32 has 32KiB of program memory. Each memory location is 16-bits wide. How many memory addresses are there? How many bits are **required** to represent the memory addresses? (not how many bits are actually used on the ATmega32).

2. (20 points) To the right of each statement, indicate the value contained in the status register and in registers **r16** and **r17**. For partial credit, show your work.

Instruction	I	T	H	S	V	N	Z	C	r16	r17
	0	0	0	0	0	0	0	0	0x00	0x00
ldi r16, 0xb8	0	0								
mov r17, r16	0	0								
andi r17, 0x0f	0	0								
dec r16	0	0								
add r16, r17	0	0								

3. (10 points) How much time will the following code segment take to execute on your SunRom board? (Just set up the equation, you don't need to solve it… Show your work)

```
        ldi  r17, 200
loop2:
        ldi  r16, 100
loop1:
        dec  r16
        brne loop1
        dec  r17
        brne loop2
```

4. (10 points) Explain how the X, Y, Z registers differ from the r0 - r31 registers.

5. (10 points) What do you know about the stack pointer? How is it used?

6. (10 points) Show the instructions necessary to initialize the stack pointer to **RAMEND-0x20**.

7. (30 points) Write a complete program that alternates between every other LED being on and then off. The LEDs should alternate on/off approximately every 0.5 seconds. You may assume that a subroutine at memory location delay_half_sec already exists.
Specifically, the LEDs should alternate between:

```
_____
|  ON  | OFF  |  ON  | OFF  |  ON  | OFF  |  ON  | OFF  |
_____
```

    and

```
_____
| OFF  |  ON  | OFF  |  ON  | OFF  |  ON  | OFF  |  ON  |
_____
```