Solutions to Assignment 5
Analog Interfaces

Question 1

```
#define CONTROL 0xFF00
#define DATA    0xFF01

#define READY   0x01
#define CONVERT 0x01

/* Do A/D converstion and return result in 2's complement format */

int convert ( )
{
  int c ;

  /* start conversion */
  spoke(CONTROL, CONVERT) ;

 /* wait for conversion to finish */
  while ( speek(CONTROL) & READY == 0 ) ;

  /* get offset-binary A/D result */
  c = (unsigned char) speek(DATA) ;

  /* return as 2's complement  */
  return c - 128 ;
}
```

Question 2

Specifications	Converter Type
1. 10 bit, 50 kHz	(b) Successive Approximation
2. 6 bit, 30 MHz	(c) Flash
3. 16 bit, 5 Hz	(a) Dual Slope

Question 3

Since the spacing increases by 1% and the frequency is proportional to the square root of the plate spacing, the frequency will increase by $\sqrt{1+0.01}$ and the new frequency will be 1.004988 MHz. In 100 ms the counter will count 100000 and 100498 cycles. This corresponds to an A/D resolution of between 8 (256) and 9 (512) bits.

Question 4

If the supply voltage is 5 volts, and the output of the gate is 0.7 volts, and the voltage across the diode is 1.5 volts, then by Kirchoff's voltage law the voltage across the resistor is $5-1.5-0.7 = 2.8$ volts. From Ohm's law a resistance of $2.8/.008 = 350\ \Omega$ will produce a current of 8 mA. The power dissipated in the resistor is $8\text{mA} \times 2.8\text{V} = 22.4$ mW. The power consumed by the LED is $8\text{mA} \times 1.5\text{V} = 12$ mW.

Question 5

(a) Before the transistor reaches saturation the ratio of collector current to base current is the current gain. If the collector current is 5 A and the gain is 2500, the base current is $5/2500 = 2$mA.

(b) If the base voltage is 0.7 V and the gate output is 3.7 V, the voltage across the resistor is $3.7-0.7 = 3.0$V. For a current of 3×2 mA $= 6$ mA, the resistance should be $3.0/.006 = 500\ \Omega$.

(c) The current dissipated by the resistor is $0.006 \times 3.0 = 0.018$ mA. The power dissipated by the transistor due to the current flowing into the collector is $0.4 \times 5 = 2$ W. The power due to the current flowing in the base circuit is neglible by comparison (0.7×0.006). The voltage across the motor is $12-0.4 = 11.6$V. The power consumed by the motor is $11.6 \times 5 = 58$ W. The transistor is operating within its specifications for collector current ($5 < 15$A), and maximum power dissipation ($2 < 90$W).

(d) Since the case-to-heatsink thermal resistance θ_{CS} is negligible, the equation for the junction temperature is

$$T_J = T_A + (\theta_{JC} + \theta_{SA})P$$

since T_A is 60 degrees C, $\theta_{JC} = 1.5$ degrees C per watt, P is 2 W, and we want $T_J < 180$ degrees C,

$$T_J = 60 + (1.5 + \theta_{SA})2 < 180$$

so

$$\theta_{SA} < (180 - 60)/2 - 1.5$$

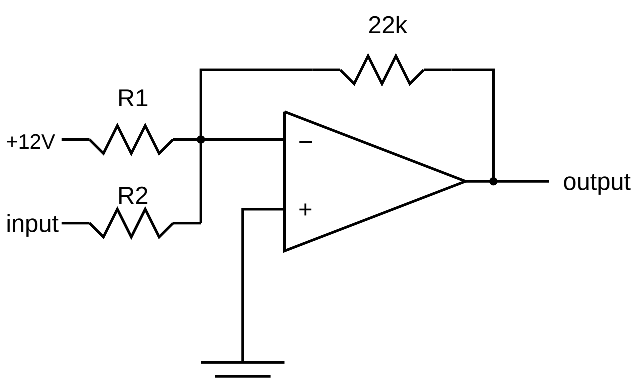
and

$$\theta_{SA} < 58.5$$

.

Question 6

The circuit shown in the question is not able to provide the correct output. The diagram should have been drawn as follows:



The best resolution would be obtained when the A/D input voltage spans the whole of the input voltage range (0 to 5 volts). From the equation (derived in a lecture) for the voltage output (v_o) of a summing amplifier we get:

$$v_o = -22000(\frac{12}{R_1} + \frac{v_i}{R_2})$$

where v_i is the input voltage from the sensor.

Since this is an inverting amplifier, a lower input voltage should give a higher output voltage, thus an input of -5.250 V should give the output of 5 volts and an input of -5.050 V should give the output of 0 volts.

Using the last two values for v_i and v_o, we can solve for R_1:

$$0 = -22000\left(\frac{12}{R_1} + \frac{-5.050}{R_2}\right)$$

$$\frac{12}{R_1} = \frac{5.050}{R_2}$$

$$R_1 = \frac{12}{5.05} R_2$$

Substituting this expression and the first pair of input/output values we obtain:

$$5 = -22000\left(\frac{12}{\frac{12}{5.05}R_2} + \frac{-5.250}{R_2}\right)$$

$$R_2 = \frac{-22000}{5}(5.05 - 5.250) = \frac{-22000}{5}(-0.2) = 880\,\Omega$$

and

$$R_1 = \frac{5.05}{12} 880 = 370\Omega$$