1. The input and output of a digital controller are denoted with $e$ and $y$ respectively. The difference equation is given as

$$y(k + 1) = y(k) + K_i e(k)$$

a. Write the transfer function $D(z)$ of this controller in z-domain (remember $D(z) = Y(z)/E(z)$).

b. Write the transfer function $D(s)$ of this controller in s-domain.

c. Comment on what type of controller it is.

2. Assume that we apply an appropriate PWM signal to drive a DC motor for speed control. When the duty cycle of PWM is 100% the motor’s speed is 1000 rpm. If the duty cycle is adjusted to 50% what would be the speed?

3. Assume a sensor circuit that detects fan blades, and creates a pulse when a blade passes through the sensor. When a 12 blade fan is placed in this sensor circuit, a square wave of 220Hz frequency is observed on the oscilloscope. What is the rotational speed (RPM) of this fan?

4. For a DC motor, the relation between the input voltage and speed is given with the equation:

$$\frac{dy}{dt} + y(t) = 100x(t)$$

where $y$ denotes the speed of the rotor in rpm, and $x$ denotes the motor input in volts. If we apply a step input $x(t) = 10u(t)$ to the motor, what would be the final value of motor speed?

5. Assume that a 8-bit successive approximation ADC has an input range of 0-5 volts and the period of clock signal of the internal 8-bit up counter is 1 $\mu$s. If we apply 2 volts DC signal to the analog input, calculate how much time it takes for the ADC to complete the conversion.

Grading: 1.a:10 pts, 1.b:5 pts, 1.c:10 pts, 2: 15 pts, For the rest, 20 pts each.