

## Physics 37100 Advanced Physics Laboratory I

### Lab #5

(PART I: PID---The Process Function)

- 1) The process function  $V(n)$  of a PID controller maps the control variable  $n$  to the process variable  $V$ . That is  $V=V(n)$ . You will make a PID controller to control the average brightness of an LED as measured by a photoresistor. In this system the process variable  $V$  will be the measured average brightness of the LED in counts 0-1023, and the control variable  $n$  will be the value sent to `analogWrite()` to change the brightness of the LED. To begin you will measure the process function  $V(n)$ . From lab 3 and 4 we know that the LED driven by `analogWrite()` is pulse-width-modulated (pwm). That means that it is actually turning on and off, but at a high enough rate to not be noticed by our eyes. In lab you found that the frequency is  $\sim 490\text{Hz}$ . Use the function `getPhoto()` (below) to measure the average brightness. `getPhoto(na,dta)` takes 2 arguments.  $na$  is the number of averages and  $dta$  is the sampling time. The exact period of the pwm output is  $2040\mu\text{s}$  so we take 15 samples at  $136\mu\text{s}$  each to give  $2040\mu\text{s}$  total. By averaging over exactly one cycle we eliminate some noise. Briefly explain why?

- a. Use `getPhoto()` to measure and plot  $V=V(n)$  for every value of  $n$   $[0,255]$ , where  $n$  is the input to `analogWrite(n)` and  $V$  is the value of `getPhoto()`. You should pause about  $100\text{ms}$  between changing `analogWrite()` and measuring the brightness using `getPhoto()`.

```
float getPhoto(int na = 15, int dta = 136) {
    int n;
    unsigned long dt;
    float vS = 0;

    for (n = 0, dt = micros(); n < na; n++) {
        while (micros() - dt < dta);
        dt = micros();
        vS += analogRead(inPin);
    }
    return (vS / na);
}
```

- b. From the plot of the process function  $V(n)$  estimate the maximum value of the variable  $P$  in a proportional controller given by the equation  $n=P*e$ , where  $e=V_{\text{set}}-V$  is the error and  $V_{\text{set}}$  is the control set point. Use  $V_{\text{set}}=V(10)$  for the estimate.