

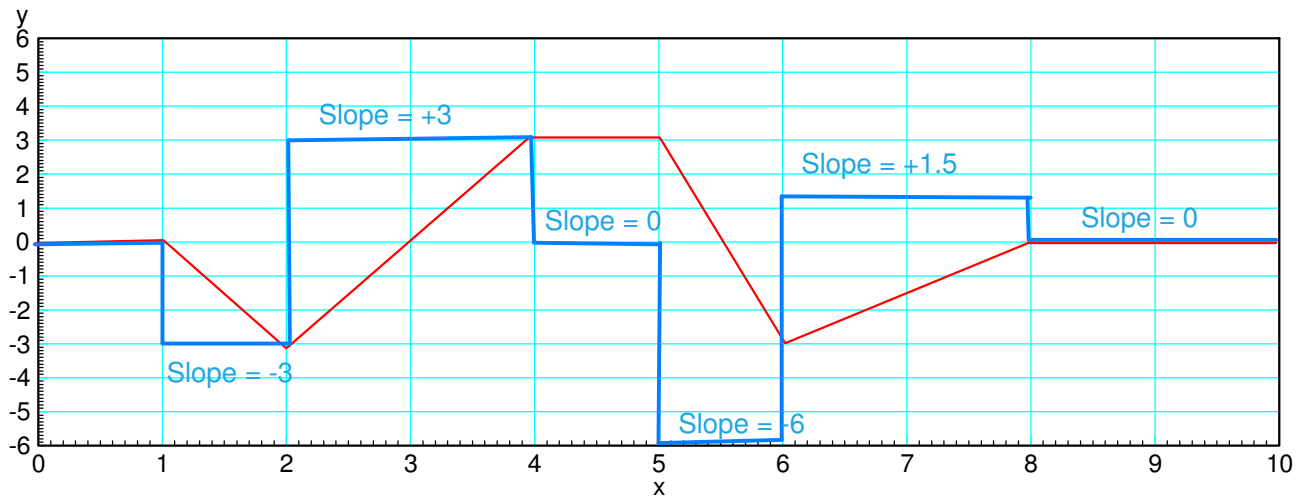
# ECE 111 - Homework #4:

Week #4: Math 165 Calculus - Due 8am Tuesday, February 8th

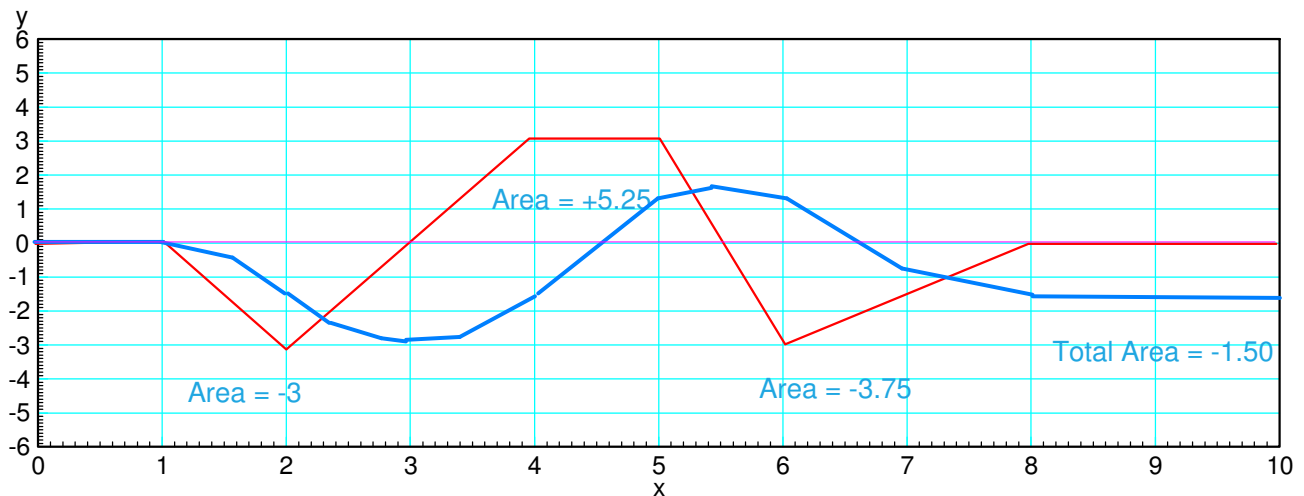
Please submit as a Word or pdf file to BlackBoard or email to Jacob\_Glower@yahoo.com with header ECE 111 HW#4  
www.BisonAcademy.com

1) Sketch the derivative of the following function

*If this is the balance of your checking account, how much money are you adding (positive) or withdrawing (negative) for the balance to be as shown?*



2) Sketch the integral of the following function



*If this is how much money you are depositing (positive) or withdrawing (negative) from your checking account, what is the balance at each instance?*

## Numerical Differentiation:

3) Use numerical methods to determine  $y(x)$

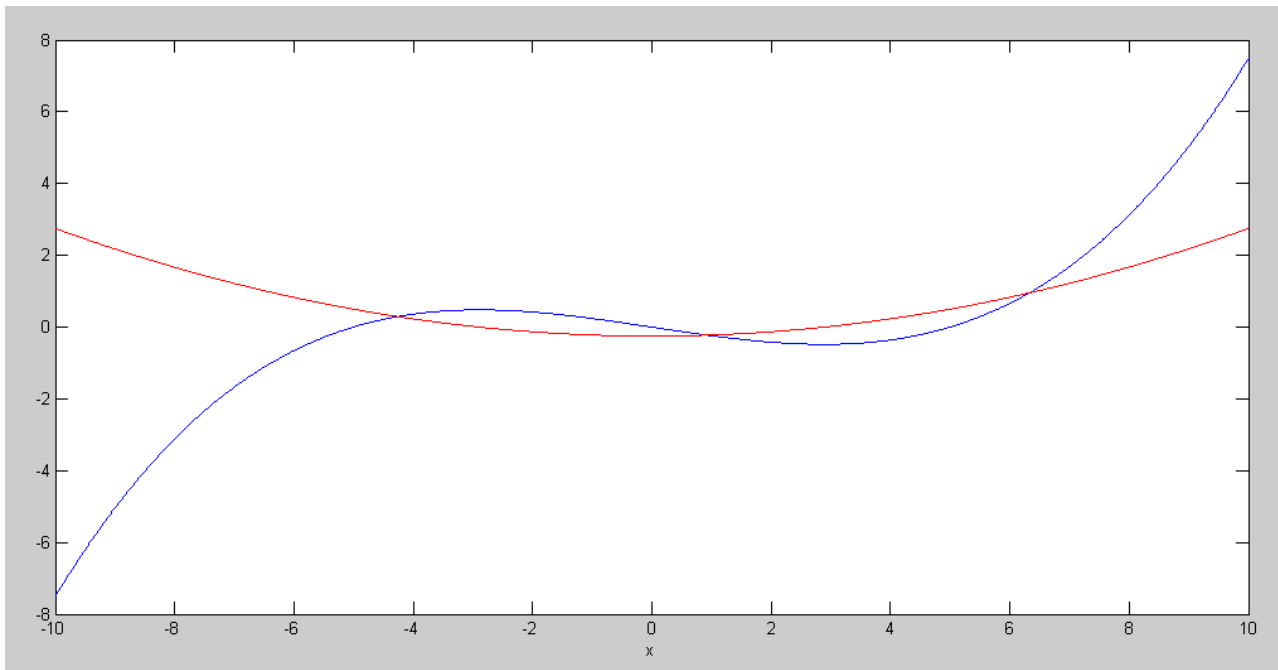
$$y = \frac{d}{dx} \left( \frac{x^3 - 25x}{100} \right)$$

for  $-10 < x < 10$ . ( a plot of  $y(x)$  is sufficient ).

```
>> x = [-10:0.01:10]';  
>> y = (x.^3 - 25*x)/100;  
>> dy = Derivative(x,y);  
>> plot(x,y,'b',x,dy,'r');  
>> xlabel('x');
```

Note:

- When  $y(x)$  is increasing, the derivative is positive
- When  $y(x)$  is decreasing, the derivative is negative
- The derivative of a cubic is a parabola (you'll cover this when you get to Math 165)
- Numerical methods allow you to compute the derivative of any function - even if you haven't had calculus yet.



$y(x)$  (blue) and  $dy/dx$  (red)

4) Use numerical methods to determine  $y(x)$

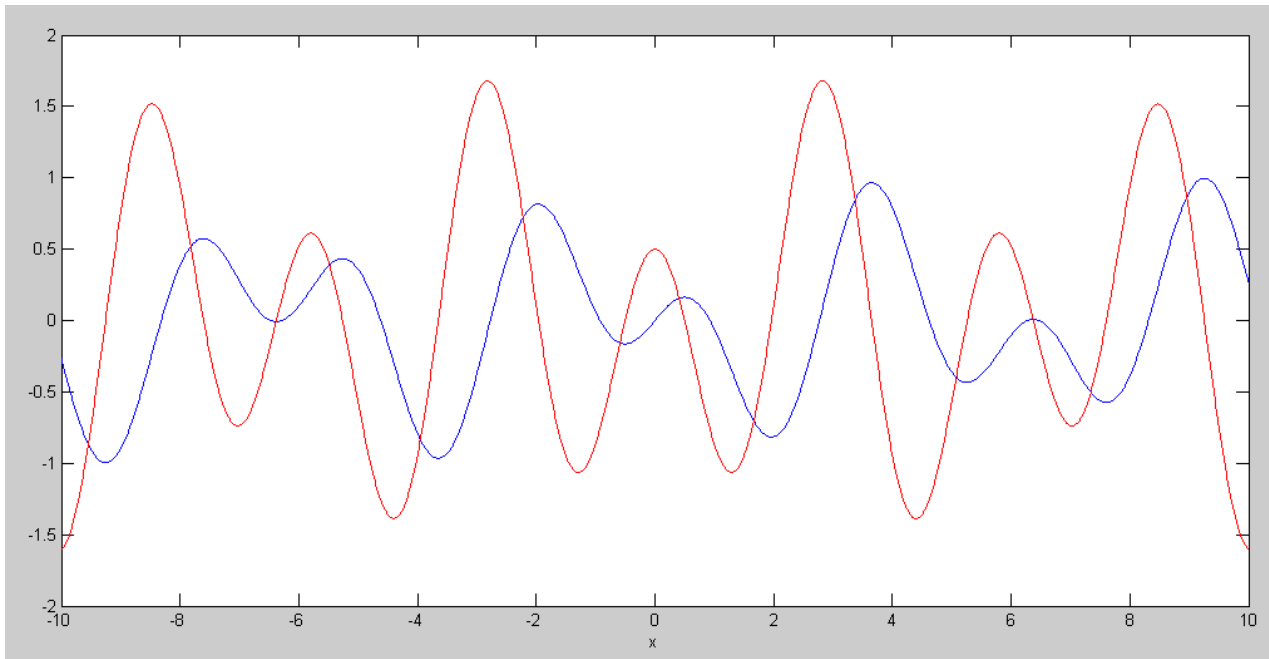
$$y = \frac{d}{dx}(\sin(0.5x) \cdot \cos(1.7x))$$

for  $-10 < x < 10$ . ( a plot of  $y(t)$  is sufficient ).

```
>> x = [-10:0.01:10]';  
>> y = sin(0.5*x) .* cos(1.7*x);  
>> dy = Derivative(x,y);  
>> plot(x,y,'b',x,dy,'r');  
>> xlabel('x');
```

Note:

- When  $y(x)$  is increasing, the derivative is positive
- When  $y(x)$  is decreasing, the derivative is neagative
- The derivative of sine wave is a cosine wave
  - you'll cover this when you get to Math 165
  - $\sin()$  and  $\cos()$  are about the only functions that have this property



## Numerical Integration

5) Use numerical methods to determine  $y(x)$

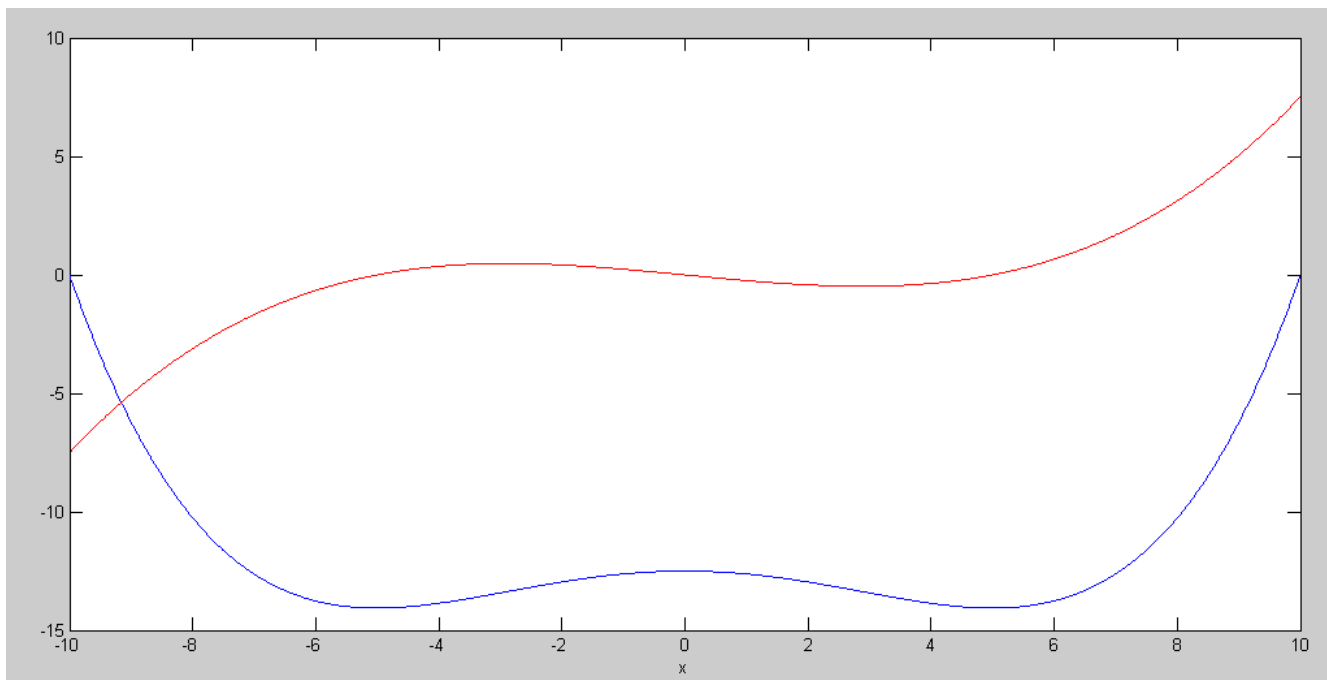
$$y = \int \left( \frac{x^3 - 25x}{100} \right) \cdot dx$$

for  $-10 < x < 10$ . ( a plot of  $y(x)$  is sufficient ). Assume  $y(-10) = 0$ .

```
>> x = [-10:0.01:10]';  
>> dy = (x.^3 - 25*x)/100;  
>> y = Integrate(x, dy);  
>> plot(x,y,'b',x,dy,'r');  
>> xlabel('x');
```

Note:

- When  $dy/dx$  is negative, the integral decreases
- When  $dy/dx$  is positive, the integral increases
- Numerical methods let you find the integral for any function even if you haven't had calculus yet



$dy/dx$  (red) and its integral (blue)

6) Use numerical methods to determine  $y(x)$

$$y = \int (\sin(0.5x) \cdot \cos(1.7x)) \cdot dx$$

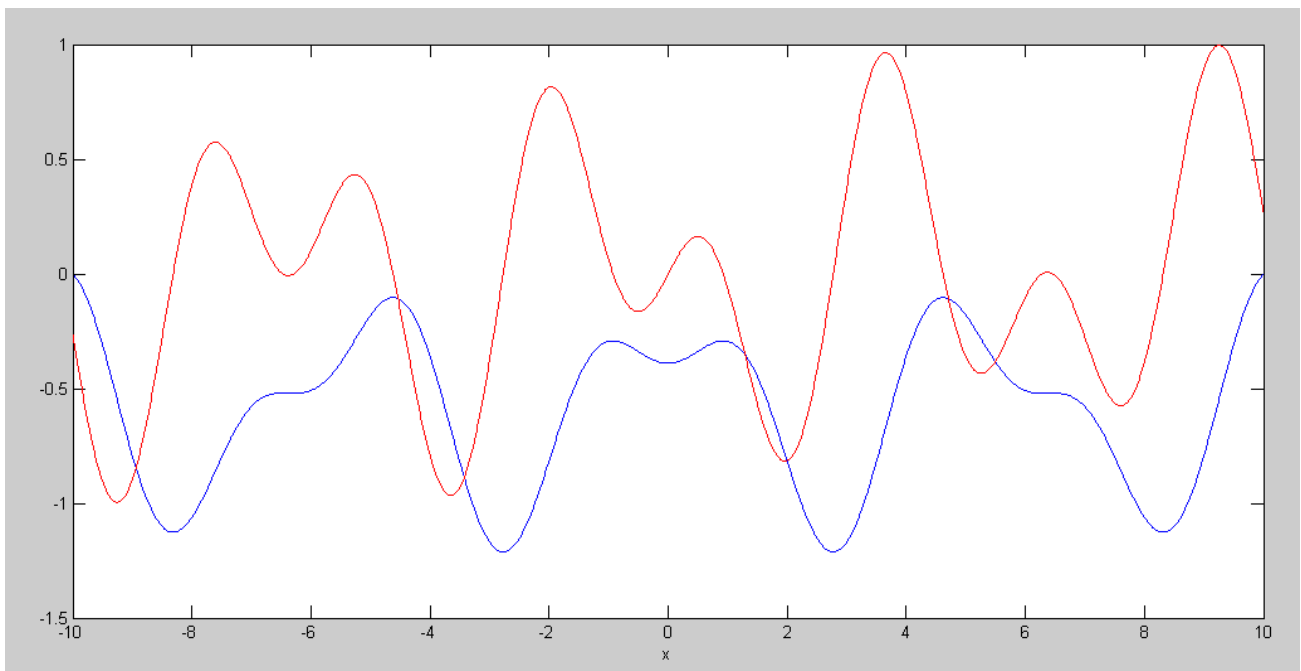
for  $-10 < x < 10$ . ( a plot of  $y(x)$  is sufficient ). Assume  $y(-10) = 0$ .

Code:

```
>> x = [-10:0.01:10]';  
>> dy = sin(0.5*x) .* cos(1.7*x);  
>> y = Integrate(x, dy);  
>> plot(x,y,'b',x,dy,'r');  
>> xlabel('x');
```

Note:

- When  $dy/dx$  is negative, the integral decreases
- When  $dy/dx$  is positive, the integral increases
- The integral of sine and cosine functions is also sine and cosine functions (about the only function with this property)



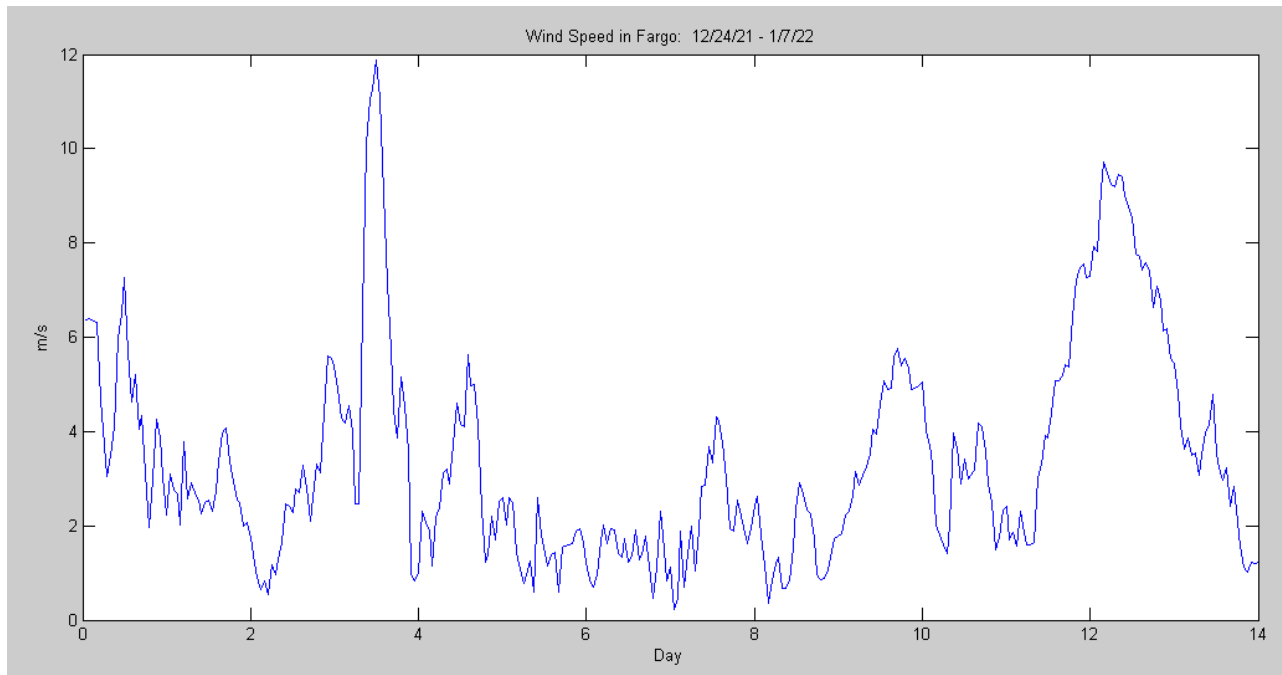
dy/dx (red) and its integral (blue)

## Wind Energy

7. Load the last 2-weeks worth of wind-speed data from NDAWN. (close to your home town if you're from North Dakota). Plot this in MATLAB as wind speed vs hour.

<https://ndawn.ndsu.nodak.edu/>

```
>> Wind = DATA;  
>> hr = [1:length(Wind)]';  
>> plot(hr/24, Wind)  
>> xlabel('Day');  
>> ylabel('m/s');  
>> title('Wind Speed in Fargo: 12/24/21 - 1/7/22');
```



8. Write a function in Matlab where you pass the wind speed at 180m (about 2.2x the wind speed at the ground) and it returns the power generated by a Vestas V164-9.5MW

Wind Speed (m/s)	0.3	4	5	6	7	8	9	10	11	12	13+
kW	0	249	613	1,226	2,030	3,123	4,444	5,900	7,299	8,601	9,500

8a) Determine a function in Matlab to approximate this curve.

Use interpolation between each point:

```
function [kW] = PowerCurve(Wind)

x = [3,4,5,6,7,8,9,10,11,12,13]';
y = [0,249,613,1226,2030,3123,4444,5900,7229,8601,9500]';

B = [x.^3, x.^2, x, x.^0];
A = inv(B'*B)*B'*y;

kW = 0*Wind;

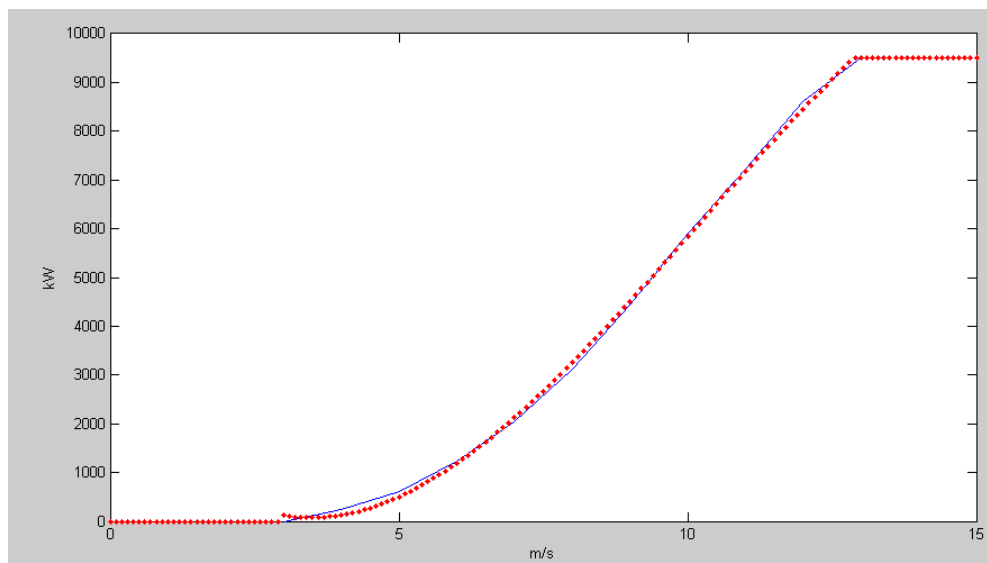
for i=1:length(kW)
    if(Wind(i) < 3)
        kW(i) = 0;
    elseif(Wind(i) > 9500)
        kW(i) = 9500;
    else
        kW(i) = [Wind(i)^3, Wind(i)^2, Wind(i), 1]*A;
    end
end

kW = min(9500,kW);
kW = max(0, kW);

plot(x,y,'b',Wind,kW,'r. ');
end
```

Check this function:

```
>> X = [0:0.1:15]';
>> PowerCurve(X)
```

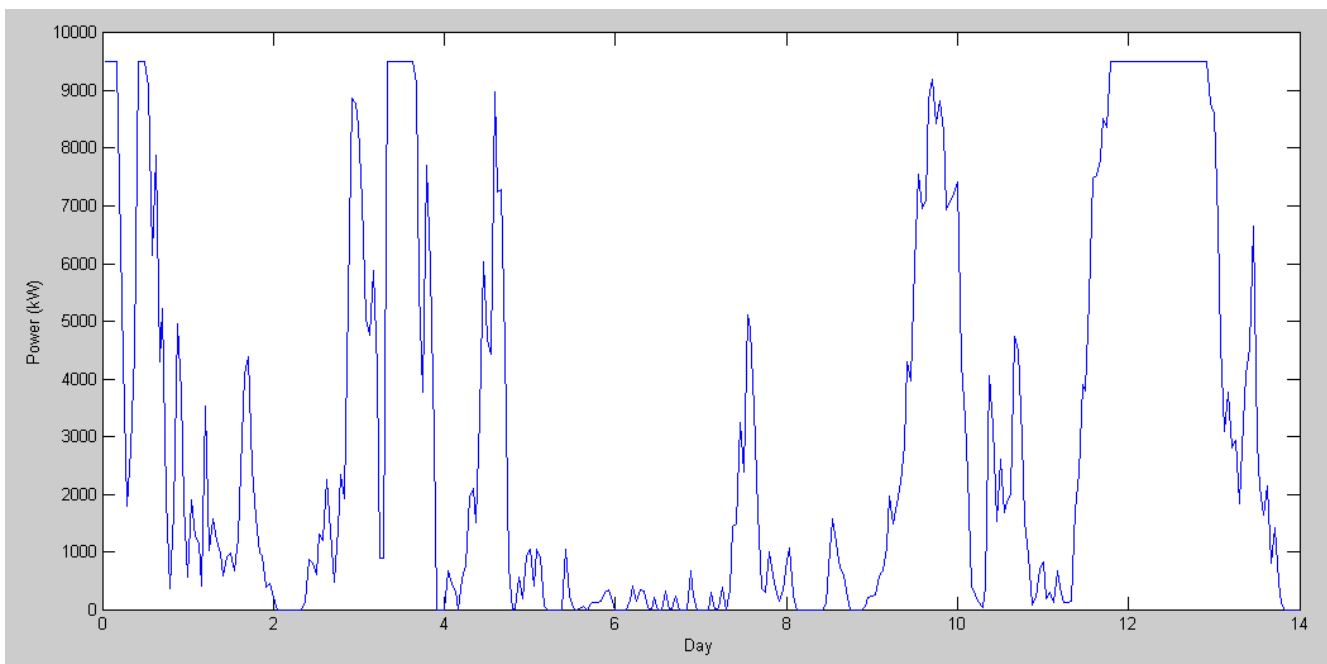


8b) Use this function to compute how much power a Vesta V164-9.5MW wind turbine would produce from the wind data your found in problem 3.

```
>> kW = PowerCurve(Wind * 2.2);  
>> plot(hr,kW);  
>> plot(hr/24,kW);  
>> xlabel('Day');  
>> ylabel('Power (kW)');  
>> mean(kW)  
  
>> mean(kW)  
  
ans = 3.0364e+003  
  
>> kWh = sum(kW)  
  
kWh = 1.0202e+006
```

The average power output of this wind turbine would be 303kW

The total power output of this wind turbine over this 2-week period is 1.02 million kWh



Predicted Power Output of a Vesta V164-9.5MW Wind Turbine in Fargo



9. It takes 1.6 pounds of North Dakota lignite coal to produce 1kWh of electricity. How many pounds of coal is this two weeks equivalent to?

```
>> Coal = 1.6 * kWh
```

```
Coal = 1.6324e+006
```

Every 2 weeks, this wind turbine would offset 1.6 million pounds of coal

10. Assume

- This wind turbine costs \$9.5 million to build, and
- You get \$0.11 / kWh for the energy you produce.

How long will it take for this wind turbine to pay for itself at this rate?

Assuming the wind is comparable throughout the year, the revenue you'd generate over 52 weeks would be:

```
>> Dollars = 0.11 * kWh * 52/2
```

```
Dollars = 2.9179e+006
```

The number of years it takes to generate \$9.5 million and pay for itself is:

```
>> years = 9.5e6 / Dollars
```

```
years = 3.2558
```



Vestas V164 9.5MW Wind Turbine