Nathan Yee
Qea Bset-4

1. .

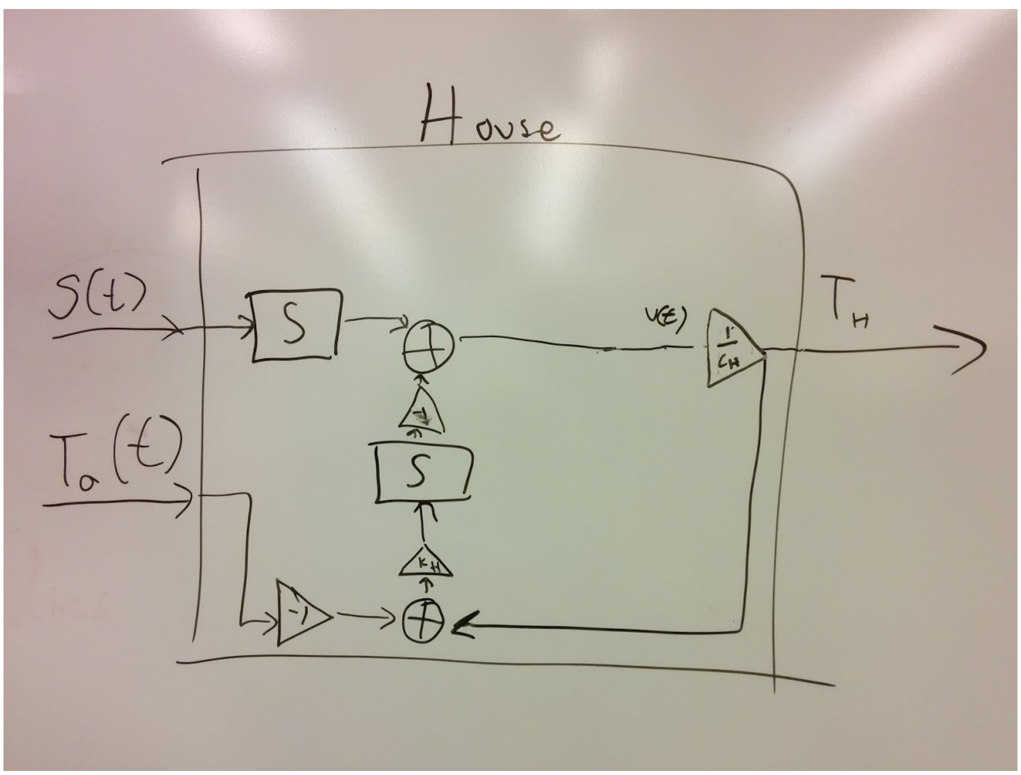
a. 

b.

$$u(t) = s(t) - P_E$$

$$u(t) = s(t) - k_H\left(T_H - T_o(t)\right)$$

$$\frac{d\,u(t)}{dt} = s(t) - k_H\left(\frac{u(t)}{c_H} - T_o(t)\right)$$

c. 

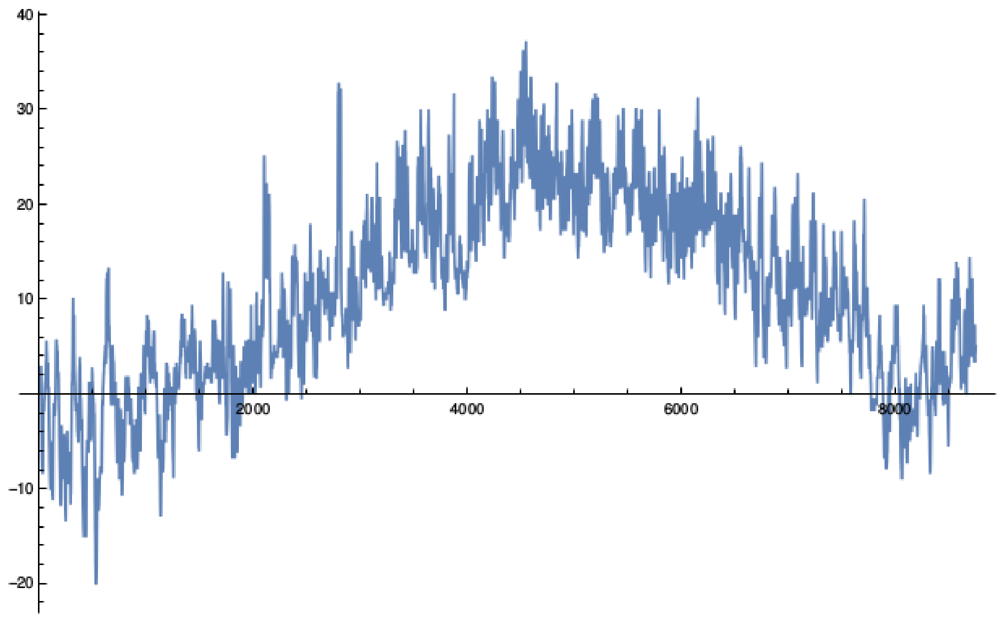
2. .

a. Temperature

Plot of temperature vs hours for the entire year. Highest temp is 36c or 96f. Lowest temp is -20c or -4f.

```
In[13]:= ListLinePlot[temp, ImageSize → Large]
```

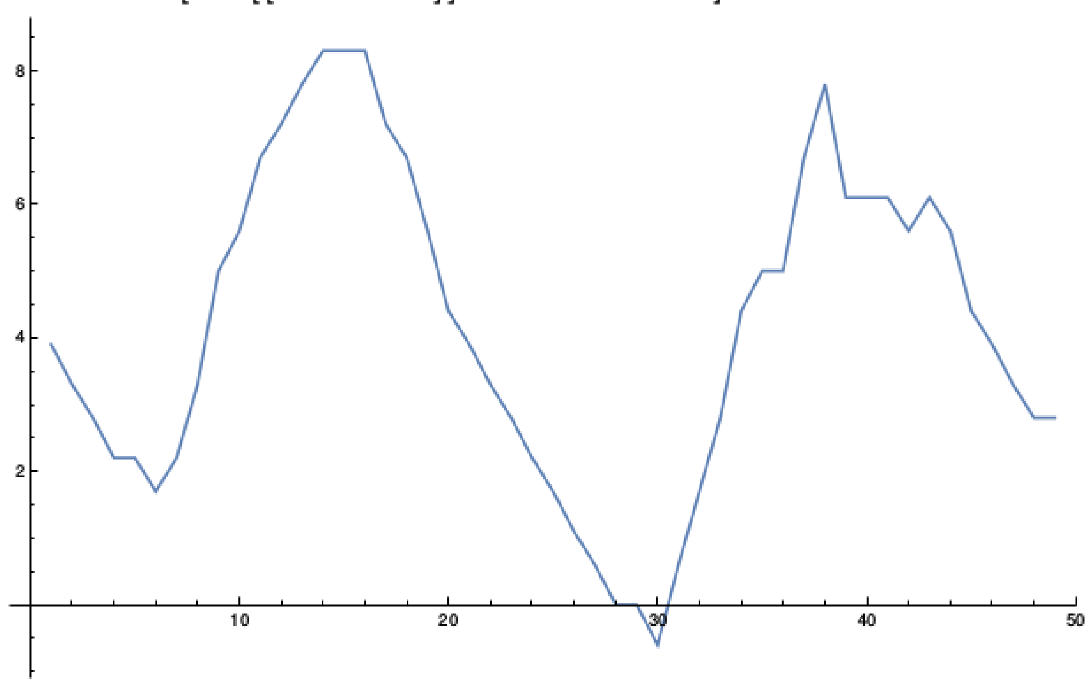
Out[13]=



Two random days during the year. The plot starts during the night and it gets colder. During daytime, the temperature increases.

```
In[9]:= ListLinePlot[temp[[2424 ;; 2472]], ImageSize → Large]
```

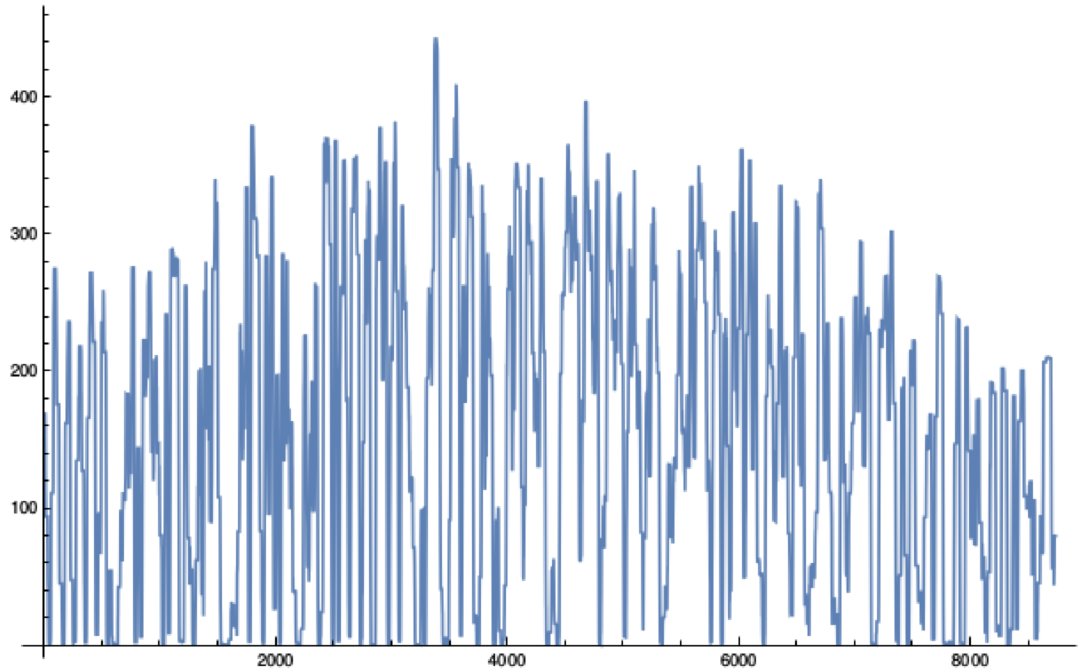
Out[19]=



Dni

Plot of dni over the course of a year. You can see that some parts are more dense than others. I think this shows that some days in the summer get more sunlight than those in the winter.

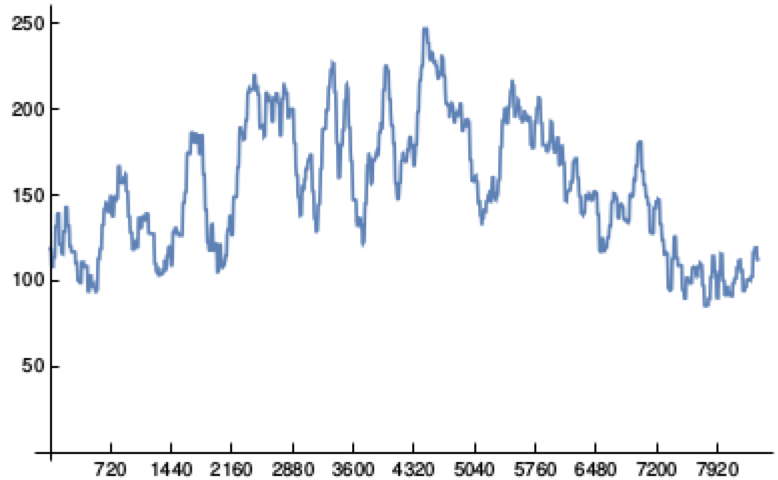
```
5]:= ListLinePlot[dni, ImageSize → Large]
```



Moving averages over the course a month

In[17]:=
```
ListLinePlot[ListConvolve[ConstantArray[1/360, 360], dni],
 Ticks → {Range[0, 8760, 24 * 30], Range[0, 250, 50]}]
```

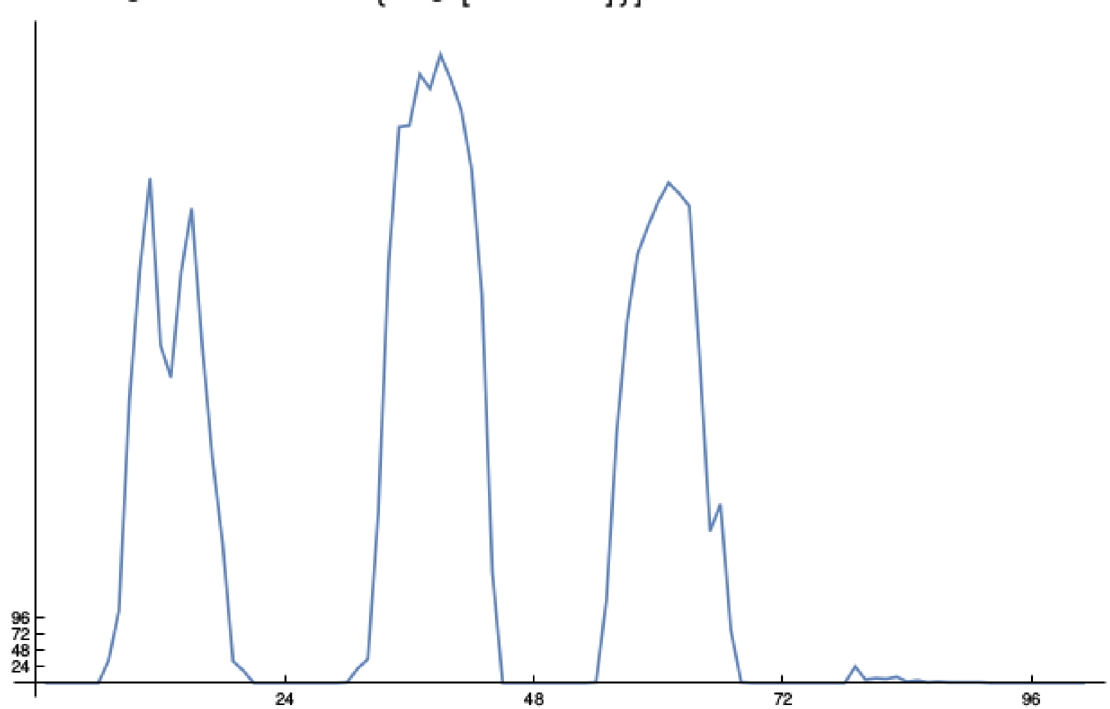
Out[17]=



Plot of dni for 5 random days. I'm interested why hours 35 to 70 have zero sunlight. Maybe there was a full day solar eclipse.

In[18]:=
```
ListLinePlot[dni[[3000 ;; 3100]], ImageSize → Large,
 PlotRange → Full, Ticks → {Range[0, 100, 24]}]
```

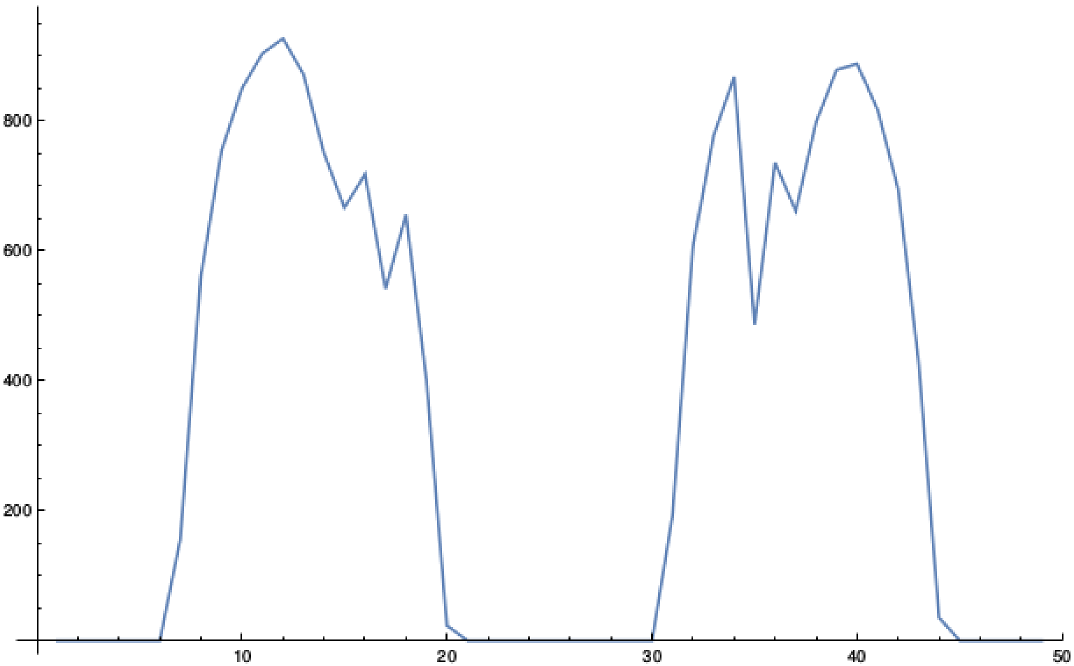
Out[18]=



Plot of dmi vs hour for the two random days. We can see daylight hours give us sunlight which increases temperature.

In[20]:= `ListLinePlot[dni[[2424 ;; 2472]], ImageSize → Large]`

Out[20]=

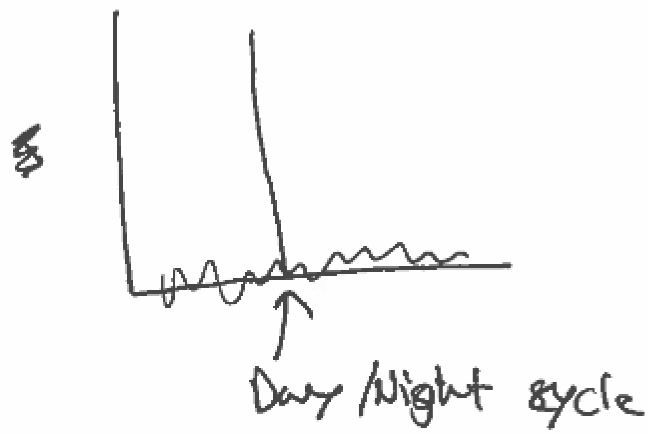


b

Predictions

should have day frequency components.

Maybe noise from clouds



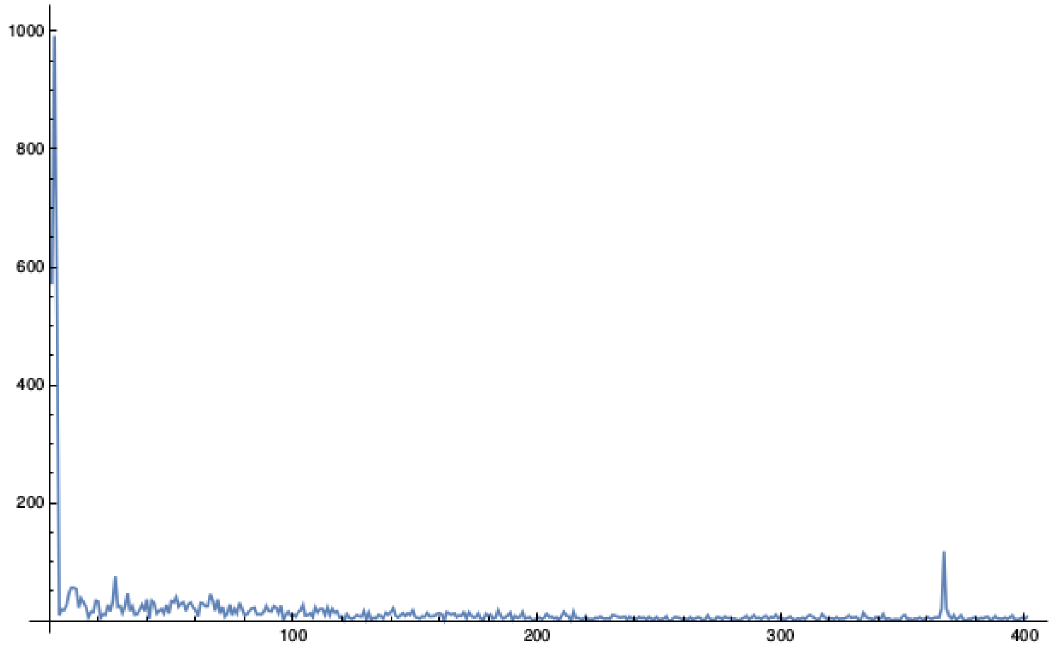
b.

c. Temperature

A zoomed in view of the temperature fft. The huge peak at the low frequency (peaks at 1000), represents the overall trend for the year. The peak at index 365ish represents the temperatures over a 24 hour period.

```
In[17]:= ListLinePlot[Abs[fftShift[temp][[Round@(Length[temp]/2) ;; Round@(Length[temp]/2) + 400]]],
  ImageSize → Large, PlotRange → All]
```

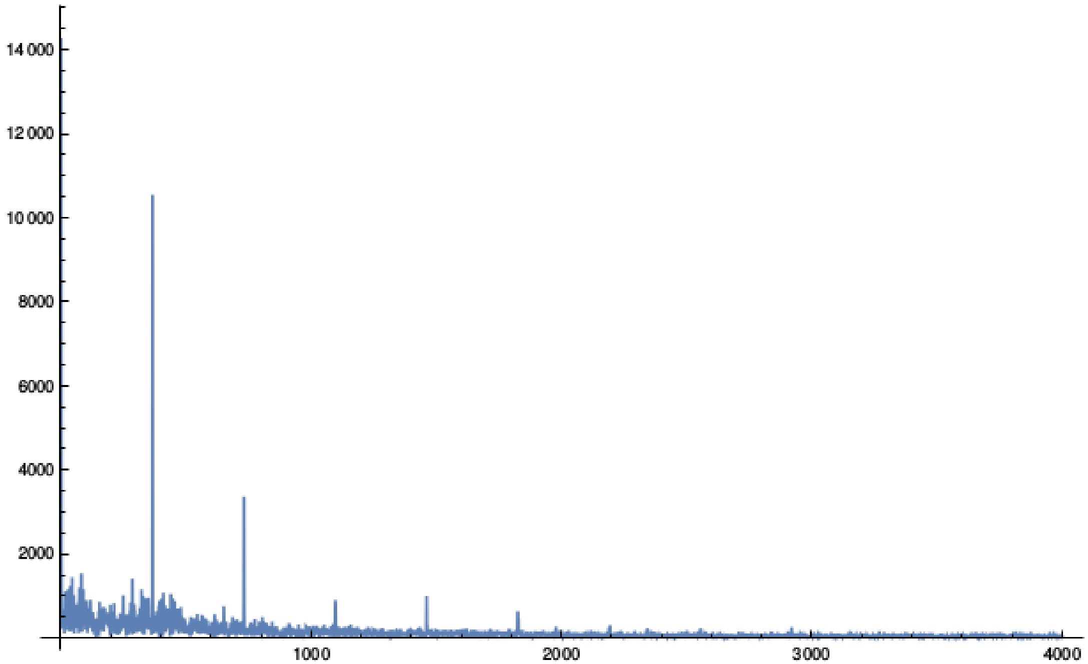
Out[17]=



Dni

In[20]:=
```
ListLinePlot[Abs[fftShift[dni][[Round@ Length[temp]/2 ;; Round@ Length[temp]/2 + 4000]]],
  ImageSize → Large, PlotRange → All]
```

Out[20]=



I don’t understand what is going on with the units. I know that the lower values represent lower frequencies while higher values represent higher frequencies. The lower frequencies show trends in the data over a long period, while the higher frequencies show trends in smaller time scales. But I still don’t understand “Please include units, particularly on the frequency axis (no, you may not label the axis from −π to π).”. I also wasn’t able to get why the Dni has more spikes and isn’t like temperature.

d. .

$$\frac{dy}{dt} =$$

I got stuck on the transfer function so I moved on. I don't really understand how we are supposed to use/make a transfer function here.

e. Didn't do anything

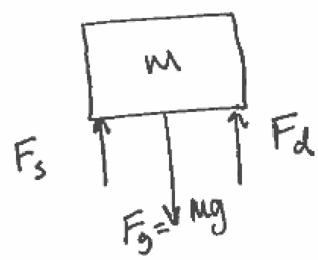
f. Didn't do anything

3. .

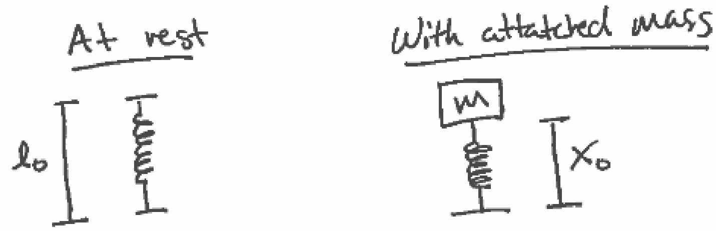
a. For a and b.

Suspension Design

③ Free body diagram, car is point mass
ⓐ so no moments



ⓑ Simplify system. What happens if we only have a spring ~~at rest.~~



When the system is not moving

$$\sum F = ma = 0$$

$$F_s = mg$$

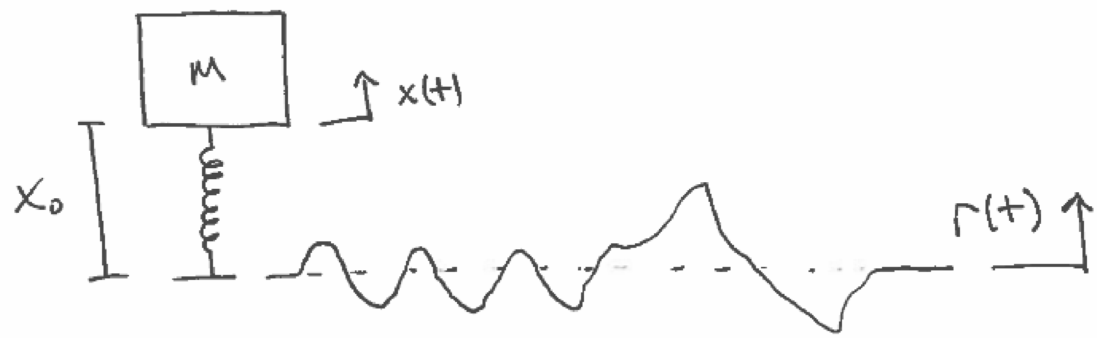
$$F_s = k\left[l_0 - X_0\right]$$

$$k \bullet \left[l_0 - X_0\right] = mg$$

When system is at rest, Force of spring is equal and opposite gravity.

③

ⓑ Next, find F_s for any length ℓ



$$\ell = X_0 + X(t) - r(t)$$

$$F_s = k\left[\ell_0 - \ell\right] = k\left[\ell_0 - (X_0 + X(t) - r(t))\right]$$

$$F_s = k\left[\ell_0 - X_0\right] - k\left[x(t) - r(t)\right]$$

Sum forces

$\cancel{\sum F = -mg \pm gravity}$

$$\sum F = -F_g + F_s$$

$$\sum F = -mg + k\left[\ell_0 - X_0\right] - k\left[x(t) - r(t)\right]$$

$$mg = k\left[\ell_0 - X_0\right]$$

$$\sum F = 0 - k\left[x(t) - r(t)\right]$$

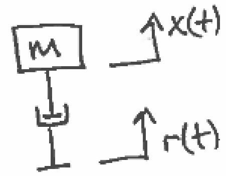
$$ma = -k\left[x(t) - r(t)\right]$$

$$m\frac{d^2x}{dt^2} = -kx(t) + kr(t)$$

$$m\frac{d^2x}{dt^2} + kx(t) = kr(t)$$

③

ⓑ Now add back in the damper



$$F_{d} = -\beta\left[\frac{dx}{dt} - \frac{dr}{dt}\right] \quad , \quad \frac{dl}{dt} = \frac{dx}{dt} - \frac{dr}{dt}$$

$$\sum F = -k\left(x(t) - r(t)\right) - \beta\left[\frac{dx}{dt} - \frac{dr}{dt}\right] = m\frac{d^2x}{dt^2}$$

$$m\frac{d^2x}{dt} + \beta\frac{dx}{dt} + k\,x(t) = k\,r(t) + \beta\frac{dr}{dt}$$

$$x(t) = \frac{1}{k}\left[k\,r(t) + \beta\frac{dr}{dt} - \beta\frac{dx}{dt} - m\frac{d^2x}{dt^2}\right]$$

$$\cancel{\pm}\,\beta\left[\frac{dx}{dt} - \frac{dr}{dt}\right]$$

$$+\beta\left[\frac{dr}{dt} - \frac{dx}{dt}\right]$$

$$\frac{dr}{dt} = \frac{-2A\pi V\sin[2\pi t V]}{L}$$

$$m\frac{d^2x}{dt} \cancel{=} \frac{1}{M}\left[k\,r(t) + \beta\frac{dr}{dt} - \beta\frac{dx}{dt} - k\,x(t)\right], \quad r(t) = \frac{A\cos 2\pi Vt}{L}$$

$A = .1\,m$

$V = 10\,m/s$

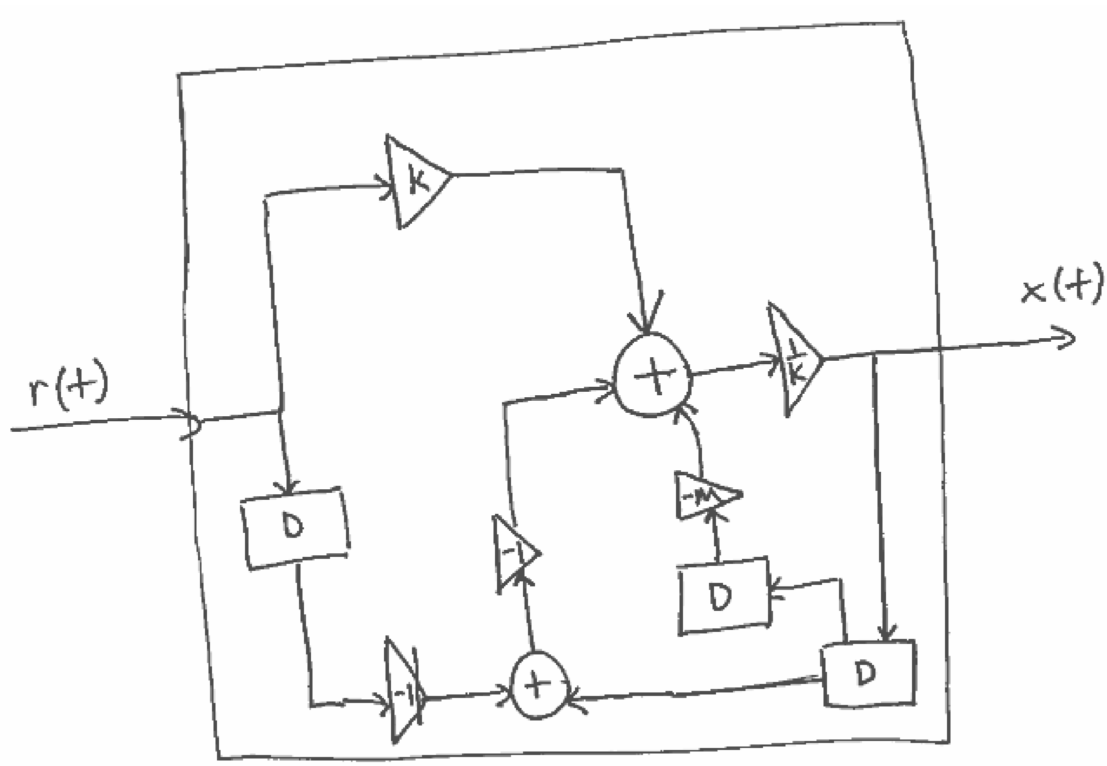
$t =$

$L = 10\,m$

$k = 10^5\,N/m$

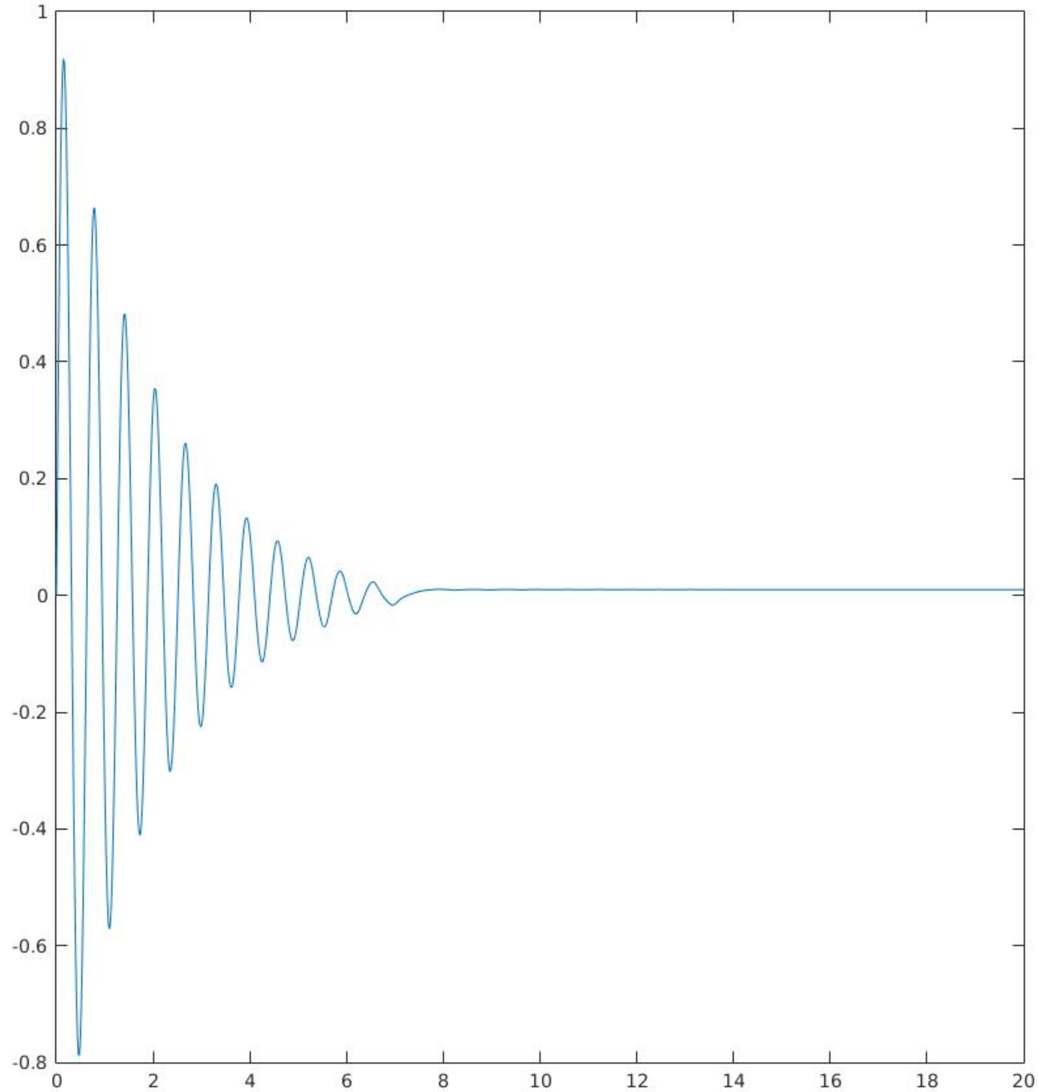
b. .

c.



Pretty picture that we didn't do anything with.

d. Used ODE45 to simulate my differential equations



e. I had done way more than 9 hours at this point and I didn't feel like doing anything more.

4. .
   a. No work done
   b. No work done
   c. No work done
   d. No work done
   e. No work done