1

a

b

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

$$u(t) = s(t) - k_{1t}\left(T_H - T_o(t)\right)$$

$$\frac{d\,u(t)}{dt} = s(t) - k_{1t}\left(\frac{u(t)}{C_H} - T_o(t)\right)$$

c

$$u(t) = \int s(t) - \int k_{1t}\left(\frac{u}{C_{1t}}(t) - T_o(t)\right)$$

$s(t)$

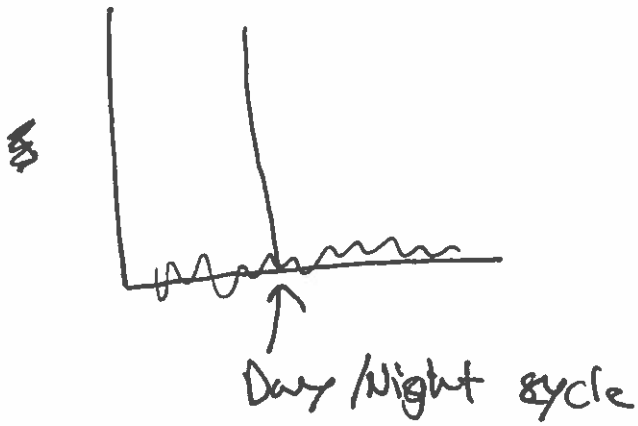
$+$

2 a

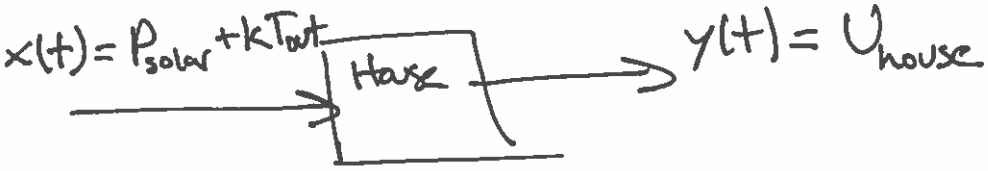
b

Predictions should have day frequency components.

Maybe noise from clouds



(d)

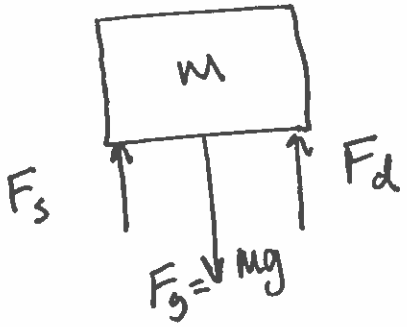


$$\frac{dy}{dt} =$$

Suspension Design

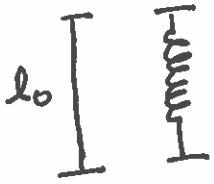
③ Free body diagram, car is point mass

ⓐ so no moments

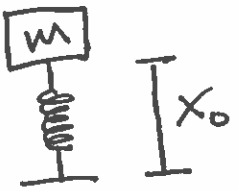


ⓑ Simplify system. What happens if we only have a spring ~~at rest.~~

At rest



With attatched mass



When the system is not moving

$$\sum F = ma = 0$$

$$F_s = mg$$

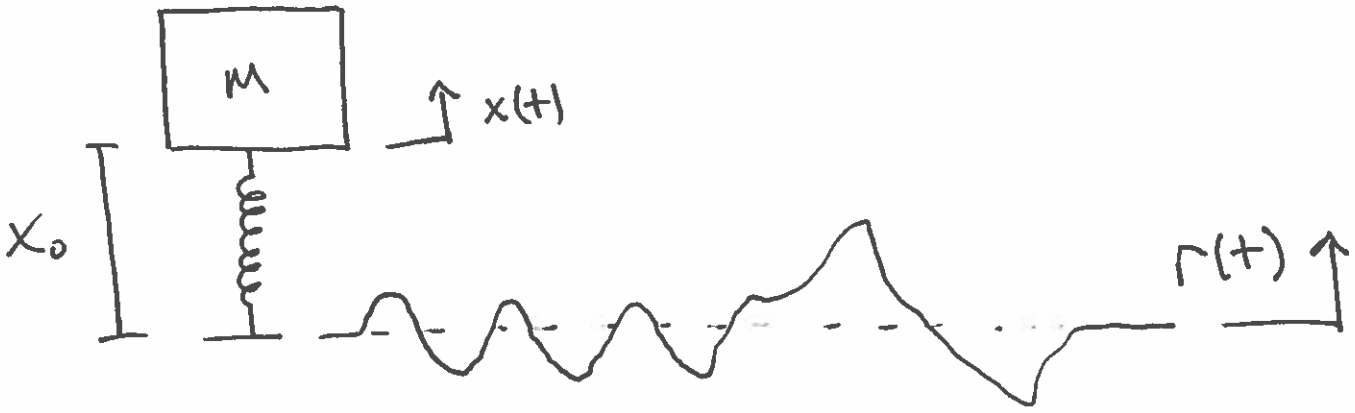
$$F_s = k\left[l_o - x_o\right]$$

$$k \cdot \left[l_o - x_o\right] = mg$$

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

(3)

(b) Next, Find F_s for any length l



$$l = x_0 + x(t) - r(t)$$

$$F_s = k[l_0 - l] = k\left[l_0 - (x_0 + x(t) - r(t))\right]$$

$$F_s = k[l_0 - x_0] - k[x(t) - r(t)]$$

Sum forces

~~$\sum F_z$ = mg + gravity~~

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

$$\sum F = -mg + k[l_0 - x_0] - k[x(t) - r(t)]$$

$$mg = k[l_0 - x_0]$$

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

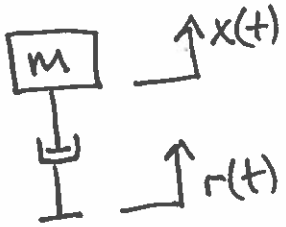
$$ma = -k[x(t) - r(t)]$$

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

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

(3)

(b) Now add back in the damper



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

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

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

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

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

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

$$\frac{dr}{dt} = \frac{-2A\pi v\,\sin\left[2\pi\frac{v}{L}t\right]}{L}$$

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

$A = .1\,m$

$V = 10\,m/s$

$t =$

$L = 10\,m$

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

$\beta = 10^3\,Ns/m$

$M = 10^3\,kg$

3

c