ME3360 Project Part 1

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a)

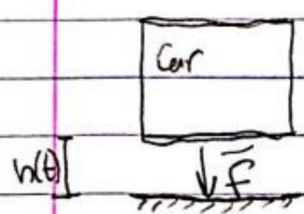
Assuming zero initial conditions and using the mass of a single train car, the only forces acting on the train car are gravity and the supporting magnetic force. In static equilibrium.

$$\sum F = 0$$

$$mg = \mathrm{F}$$

$$(5.9 \times 10^4 kg)\left(9.8\frac{m}{s^2}\right) = F$$

$$F = 5.782 \times 10^5 N$$



assume viscous damping is negligible

$m = 5.9 \times 10^4$ kg

assuming this mass is for an empty car.

assume force acts straight down.

ar

assume force is distributed evenly throughout car.

assume one car

$\bar{F} = mg = (5.9 \times 10^4 \text{ kg})(9.8 \text{ m/s}) = 5.782 \times 10^5$ N

b)

$$m\ddot{x} = \frac{21}{20}\bar{F} - mg$$

$$ms^2X(s) = \frac{21\bar{F}}{20}\left(\frac{1}{s}\right)$$

$$X(s) = \frac{1}{m}\left(\frac{21\bar{F}}{20} - g\right)\left(\frac{1}{s^3}\right)$$

$$X(s) = \frac{1}{2m}\left(\frac{21\bar{F}}{20m} - mg\right)\frac{2}{s^3}$$

$$For\ t = 0\ to\ t = 2$$

$$X(t) = \frac{1}{2m}\left(\frac{21\bar{F}}{20m} - mg\right)t^2$$

$$V(t) = \frac{1}{m}(\frac{21\bar{F}}{20m} - mg)t$$

$$For\ t = 2\ to\ t = \infty$$

$$m\ddot{x} = \bar{F} - mg$$

$$ms^2X(s) - sX(2) - v(2) = 0$$

$$X(s) = \frac{v(2)}{s^2} + X(2)$$

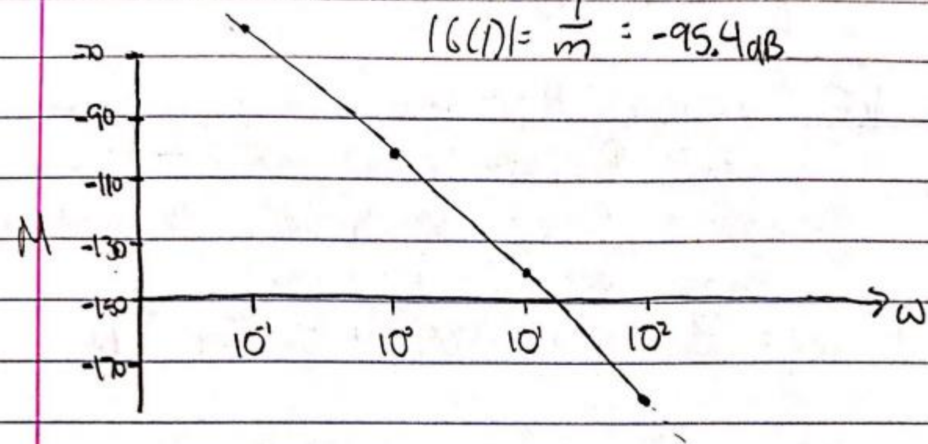
$$X(t) = v(2)t + X(2)$$

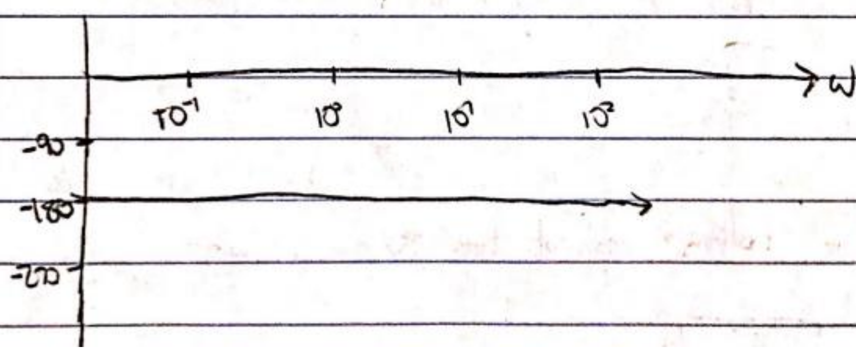
c)

c. $\frac{H(s)}{F(s)} = \frac{1}{ms^2} = G(s)$ $\quad |G(j\omega)| = \frac{1}{mj^2\omega^2}$ → -40 dB/dec slope

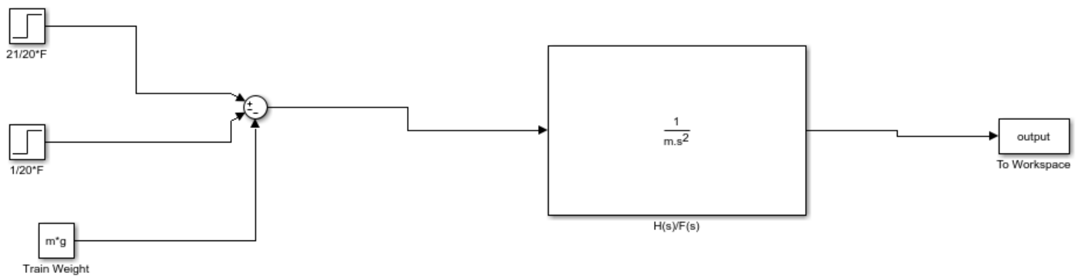
-180° phase shift

$|G(1)| = \frac{1}{m} = -95.4\,dB$

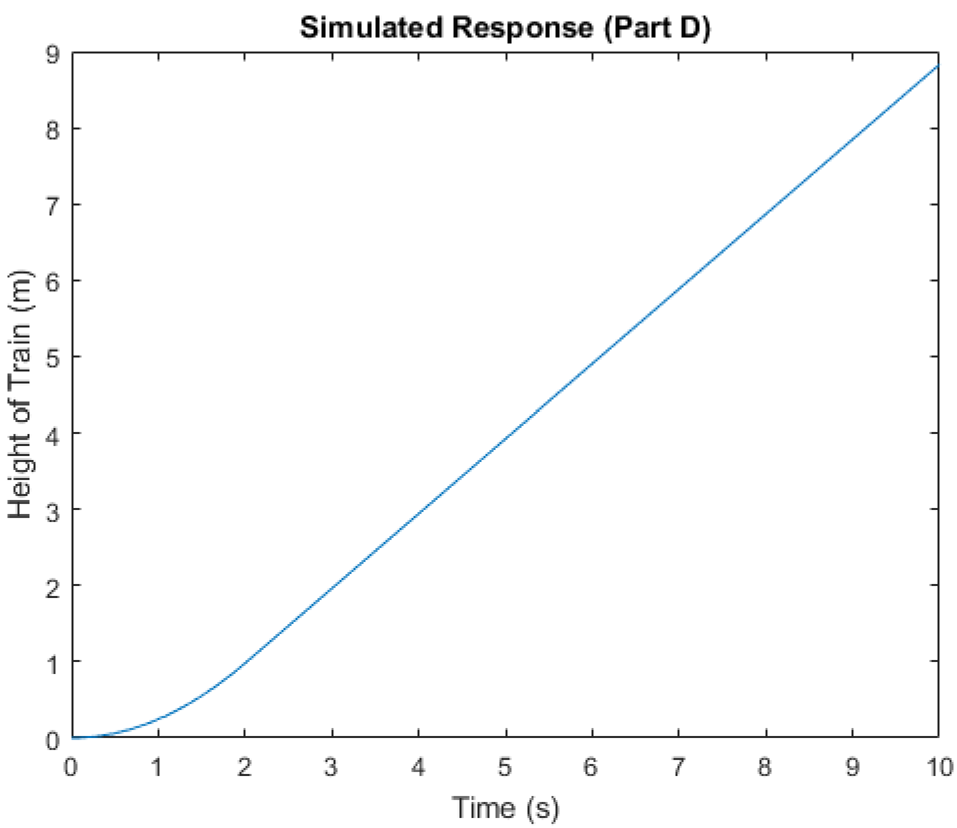




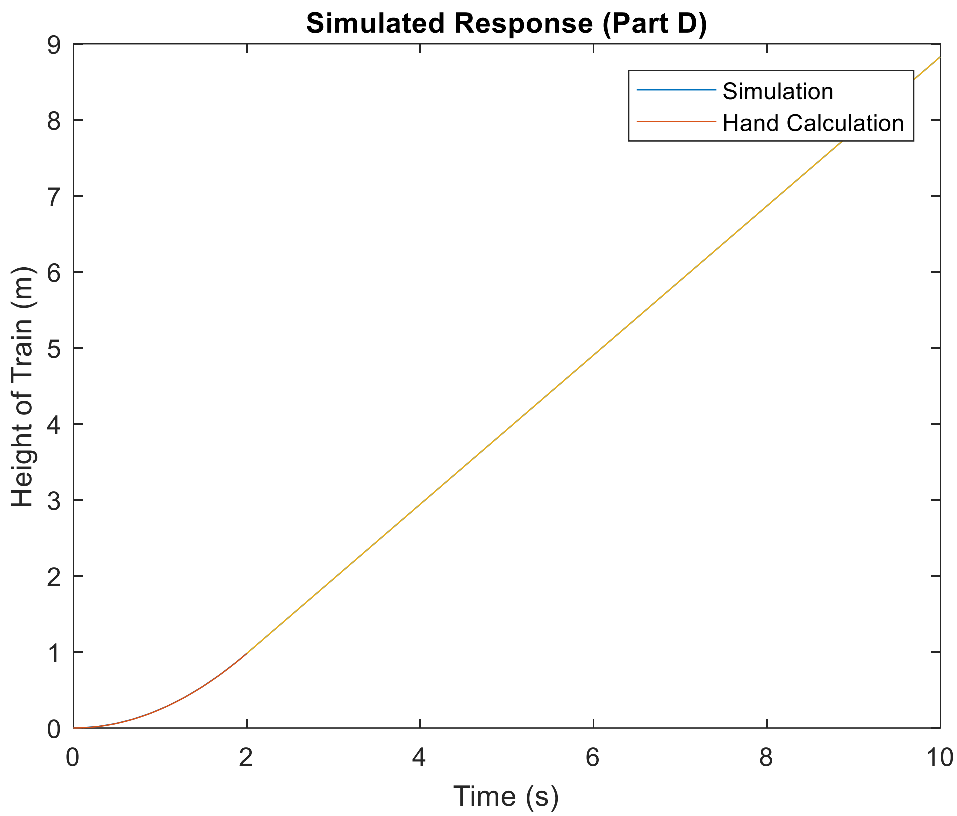
d)



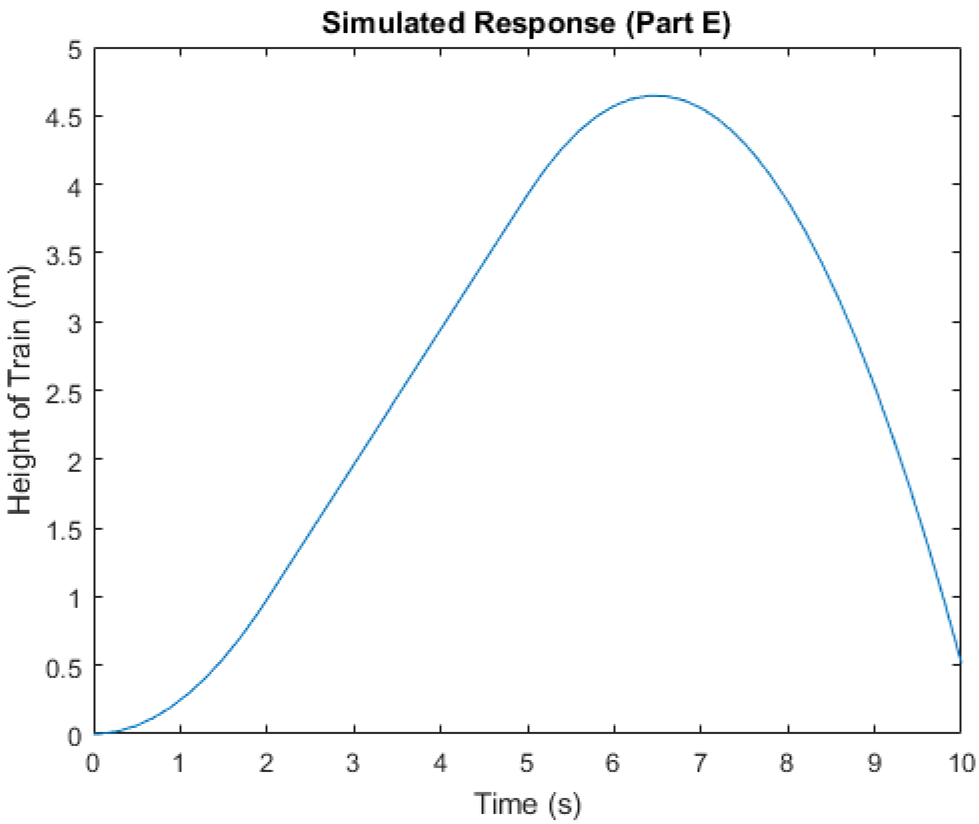
21/20*F
1/20*F
m*g
Train Weight
1
m.s2
H(s)/F(s)
output
To Workspace

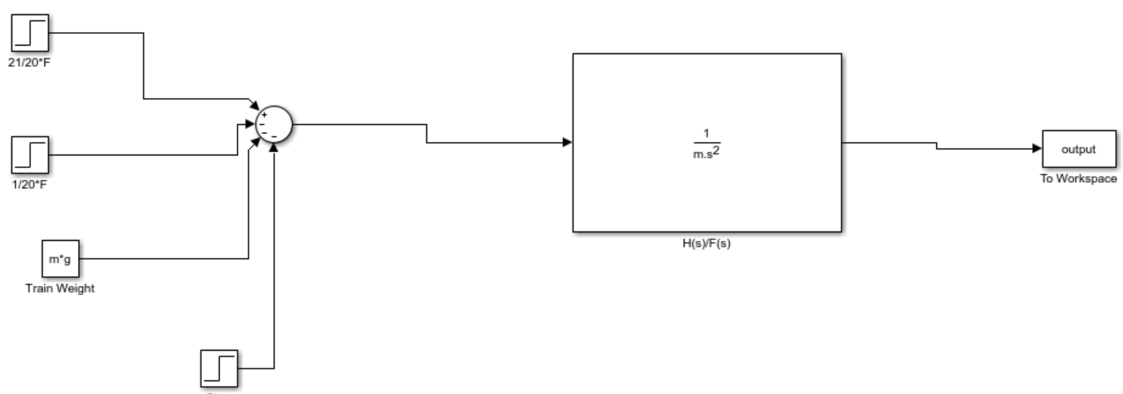


Simulated Response (Part D)
Height of Train (m)
Time (s)
0
1
2
3
4
5
6
7
8
9
10


Simulated Response (Part D)
Height of Train (m)
Time (s)
Simulation
Hand Calculation
0
1
2
3
4
5
6
7
8
9
0
2
4
6
8
10

e)


Simulated Response (Part E)
Height of Train (m)
Time (s)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
1
2
3
4
5
6
7
8
9
10


21/20*F
1/20*F
m*g
Train Weight
Step
1
m.s2
H(s)/F(s)
output
To Workspace

Matlab Code

```
clear all
close all


m=5.9*10^4; %kg
g=9.81;     %m/s^2
F=m*g;

xt=@(t) 1/(2*m)*(21/20*m*g-m*g)*t.^2;
t2=linspace(0,2);
h=xt(t2);

vt=@(t) 2*(1/(2*m)*(21/20*m*g-m*g)*t);
v2=vt(2);

h0=xt(2);
xs=@(t) v2*t-h0;
t10=linspace(2,10);
h2=xs(t10);

sim('ME3360_Part_1_D')
figure(1)
plot(tout, output)
hold on
title('Simulated Response (Part D)')
xlabel('Time (s)')
ylabel('Height of Train (m)')
plot(t2,h)
plot(t10,h2)
legend('Simulation','Hand Calculation')

hold off
%%

m=5.9*10^4; %kg
g=9.81;     %m/s^2
F=m*g;

sim('ME3360_Part_1_E')
figure(2)
plot(tout, output)
title('Simulated Response (Part E)')
xlabel('Time (s)')
ylabel('Height of Train (m)')
```