Problem 1

Side wall specs : P225/55 R18 97H

width of the tire - 225m
side wall height = 225 x .55 = 123.75
wheel diameter = 18 inches = 457.2mm

$$\text{tire radius} = \frac{457.2 + 2(123.75)}{2}$$
$$= 352.35$$

The load index is 97
so each tire can carry 1609 lbs

Therfore all 4 tires can carry 1609 x 4
= 6436 lbs
The weight of the car is 3322 lbs

so the car can safely carry ~~3322 64~~
6436 - 3322 = 3114 lbs

The speed rating is H which correlates to a maximum speed off 130 mph or 210 km/hr

$$\text{The angular speed} = \frac{V(m/s)}{R_t(m)}$$

$$V = 210 \frac{km}{hr} \times \frac{1hr}{60 \times 60 s} \times \frac{1000m}{1km} = 58.33 m/s$$

$$\omega = \frac{58.33}{0.352} = 165.55 \text{ rad/s}$$

problem 2.

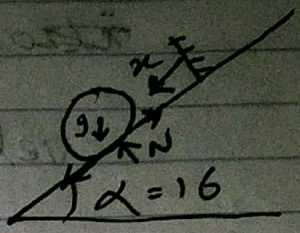
Tire specs → P215/80R16

$\alpha = 18°$

$m = 1000N$

$I = 1.1\ kg.m^2$

$\ddot{x}(20) = ?$



Solution

sidewall height = $215 \times .80 = 172\ mm$

Tire diameter = $(16 \times 25.4) + 2(172) = 750.4\ mm$

Tire radius = $750.4/2 = 375.2\ m$

sum of forces in the x direction

$$m\ddot{x} = mg\sin\alpha - F_f \quad \text{—①}$$

Sum of moments

$$I\ddot{\theta} = F_f R \quad \text{—②}$$

$$x = R\theta \rightarrow \ddot{x} = R\ddot{\theta} \quad \text{—③}$$

Substituting ③ in ②

$$I\left(\frac{\ddot{x}}{R}\right) = F_f R \Rightarrow F_f = \frac{I}{R^2}\ddot{x} \quad \text{—④}$$

Substituting ④ in ①

$$m\ddot{x} = mg\sin\alpha - \frac{I}{R^2}\ddot{x}$$

$$\ddot{x} = \frac{mg\sin\alpha}{m + \frac{I}{R^2}} = \frac{1000\sin\alpha}{\frac{1000}{9.81} + \frac{1.1}{0.375.2^2}}$$

~~$\ddot{x} = 3.03\ m/s^2$~~ ~~$2.85\ m/s^2$~~

$\ddot{x} = 2.9\ m/s^2$

since $\dot{x}(0) = 0$

~~$\ddot{x} = 20$ $\dot{x}(20)$~~

velocity after 20m $= \sqrt{2 \ddot{x} \Delta x}$

~~$V_f = \sqrt{2(3.03)(20)}$~~

~~$V_f = \sqrt{2(9.8)(20)}$~~ $V_f = \sqrt{2(2.9)(20)}$

~~$V_f = 10.6747 \text{ m/s} = 23.73 \text{ mph}$~~

$V_f = 10.78 \text{ m/s} = 24.2 \text{ mph}$

problem 3.

$P = 750w$

$t_1 = 8s$

$t_2 = 5s$

$\dot{x}(0) = 2mph$

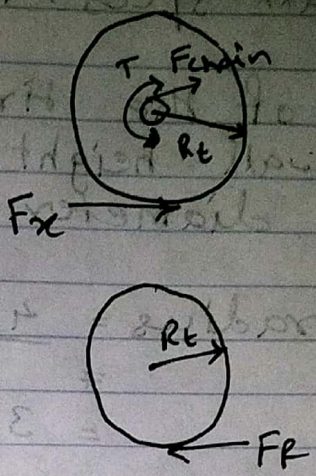
$m_{cyclist} = 100kg$

$m_{bike} = 12\,kg$

$I_{tire} = 0.2\,m$

$R_{tire} = 0.4m$

$R_2/R_1 = 11/53$



using the formula derived :

$$\ddot{x} = \frac{\frac{R_2}{R_1}\cdot\frac{1}{R_t}(T_p)}{(m_{cyclist}+m_{bike})+\frac{2I_t}{R_t^2}} = \frac{\frac{R_2}{R_1}\frac{1}{R_t}\left(\frac{P}{\dot{\theta}_p}\right)}{M+\frac{2I_t}{R_t^2}}$$

$$F_{ax} = \frac{\frac{R_2}{R_1}T_p - I_t\ddot{\theta}_t}{R_t} = \frac{\frac{R_2}{R_1}\left(\frac{P}{\dot{\theta}_p}\right) - I_t\frac{\ddot{x}}{R_t}}{R_t}$$

$$F_f = \frac{I_t}{R_t}\ddot{\theta}_t = \frac{I_t}{R_t}\frac{\ddot{x}}{R_t} = \frac{I_t\ddot{x}}{R_t^2}$$

Problem 4

conversion for hp to torque

$$\text{torque} = \frac{hp \times 5252}{RPM}$$

conversion for hp to kw

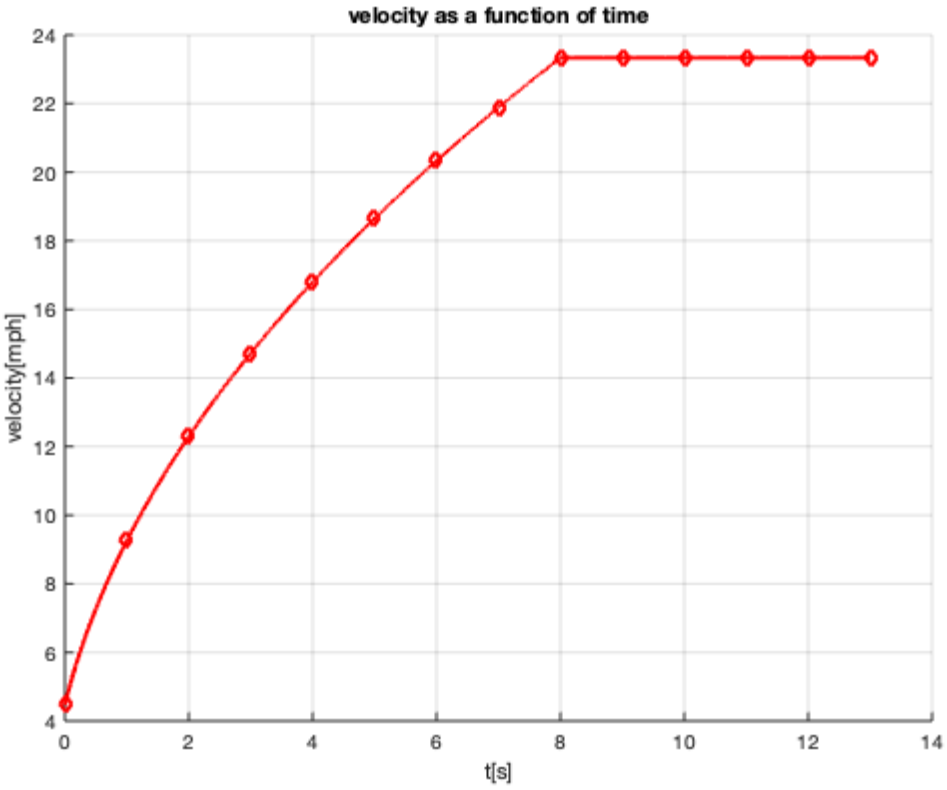
$$1hp = 0.7457\ kw$$

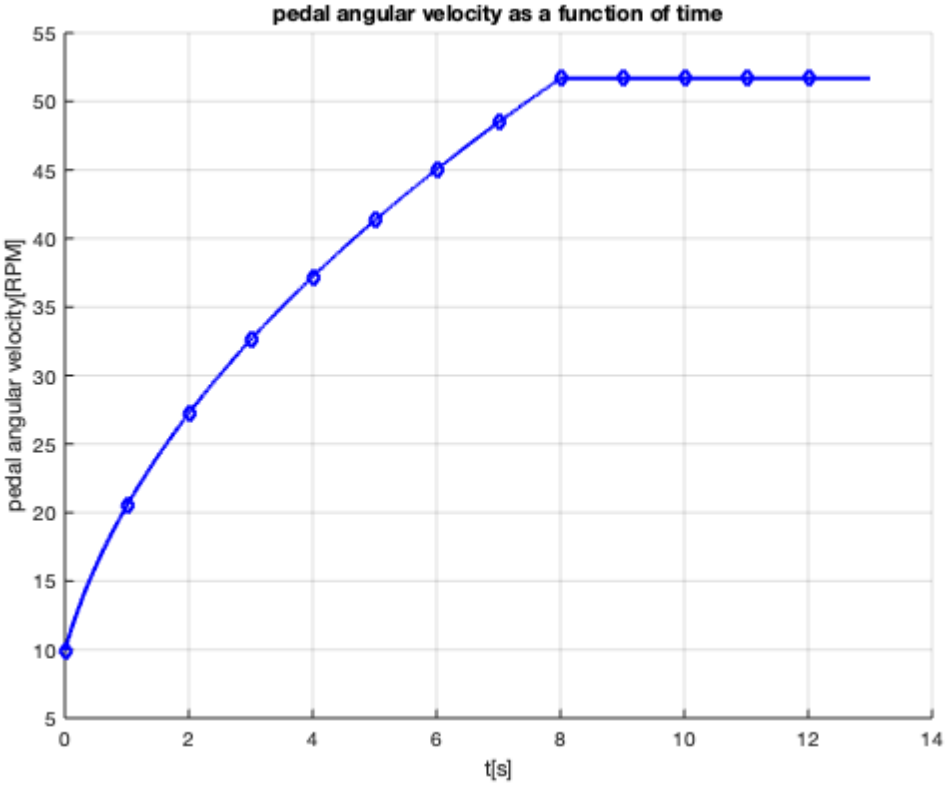
conversion for lb.ft to N.m

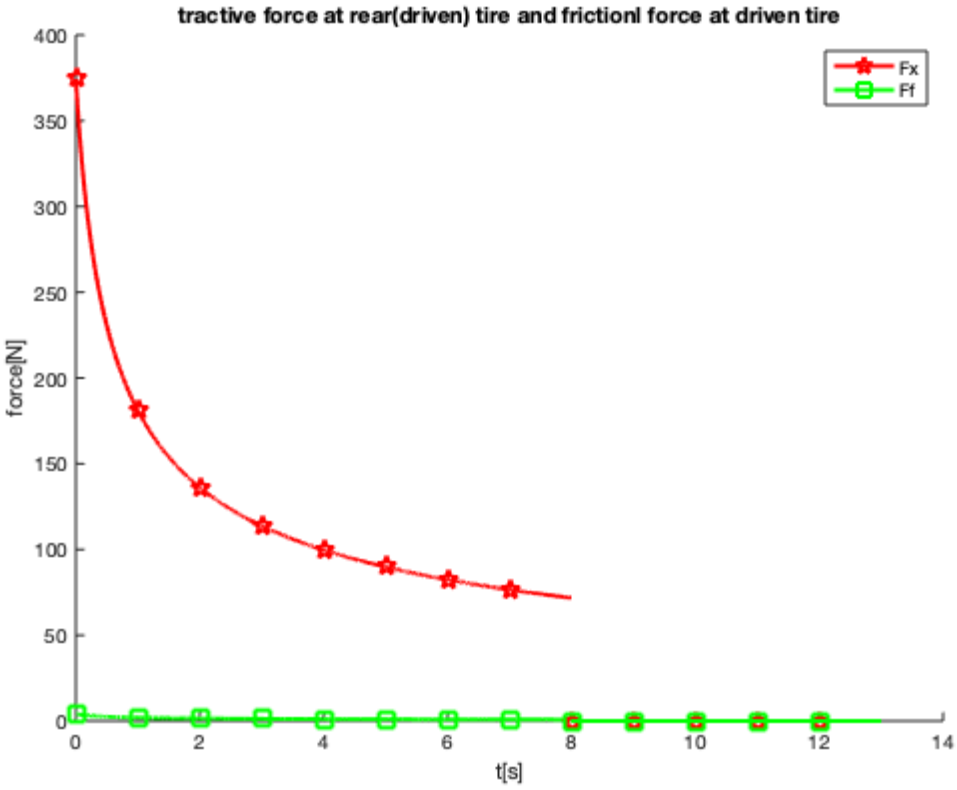
$$N.m = \frac{lb.ft}{0.73756}$$

```
M = 112;
It = 0.2;
Rt = 0.4;
P = 750;
P2 = 0;
GR = 11/53;

dt = 0.001;
N1 = 8001;
N2 = 5001;
t1 = (0:dt:(N1-1)*dt);
t2 = linspace(8,13,5001);
x(1) = 0;
xdot(1) = 2;

for k = 1:N1-1

thetap_dot(k) = (1/Rt)*GR*xdot(k);
xddot(k) = ((GR/Rt)*(P/thetap_dot(k)))/(M+2*It/Rt^2);
xdot(k+1) = xdot(k) + xddot(k)*dt;
x(k+1) = x(k) + xdot(k)*dt;
   Fx(k) = ((GR/Rt)*(P/thetap_dot(k)))-(It*xddot(k));
   Ff(k) = (It*xddot(k))/Rt^2;
end
xc(1) = 57.3373;
xdotc(1) = 10.4308;
for i = 1:N2-1

thetap_dotc(i) = (1/Rt)*GR*xdotc(i);
xddotc(i) = ((GR/Rt)*(P2/thetap_dotc(i)))/(M+2*It/Rt^2);
xdotc(i+1) = xdotc(i) + xddotc(i)*dt;
xc(i+1) = xc(i) + xdotc(i)*dt;
   Fxc(i) = ((GR/Rt)*(P2/thetap_dotc(i)))-(It*xddotc(i));
   Ffc(i) = (It*xddotc(i))/Rt^2;
end
figure(1)
hold on
plot(t1,xdot*2.23694,'-dr','Markerindices',1:1000:8000,'linew',2)
plot(t2,xdotc*2.23694,'-dr','Markerindices',1:1000:8000,'linew',2)
grid on
hold off
xlabel('t[s]')
ylabel('velocity[mph]')
title('velocity as a function of time')
figure(2)
hold on
plot(linspace(0,8,8000),thetap_dot*(30/pi),'-db','Markerindices',1:1000:8000,'linew',2)
plot(linspace(8,13,5000),thetap_dotc*(30/pi),'-db','Markerindices',1:1000:5000,'linew',2)
grid on
hold off
ylabel('pedal angular velocity[RPM]')
xlabel('t[s]')
title('pedal angular velocity as a function of time')
figure(3)
hold on
plot(linspace(0,8,8000),Fx,'-pr','Markerindices',1:1000:length(Fx),'Markersize',10,'linew',2)
plot(linspace(0,8,8000),Ff,'-sg','Markerindices',1:1000:length(Ff),'Markersize',10,'linew',2)
plot(linspace(8,13,5000),Fxc,'-pr','Markerindices',1:1000:length(Fxc),'Markersize',10,'linew',2)
plot(linspace(8,13,5000),Ffc,'-sg','Markerindices',1:1000:length(Ffc),'Markersize',10,'linew',2)
```

```
xlabel('t[s]')
ylabel('force[N]')
title('tractive force at rear(driven) tire and frictionl force at driven tire')
legend('Fx','Ff')
hold off
```


velocity as a function of time
velocity[mph]
t[s]
4
6
8
10
12
14
16
18
20
22
24
0
2
4
6
8
10
12
14


pedal angular velocity as a function of time
pedal angular velocity[RPM]
t[s]
5
10
15
20
25
30
35
40
45
50
55
0
2
4
6
8
10
12
14



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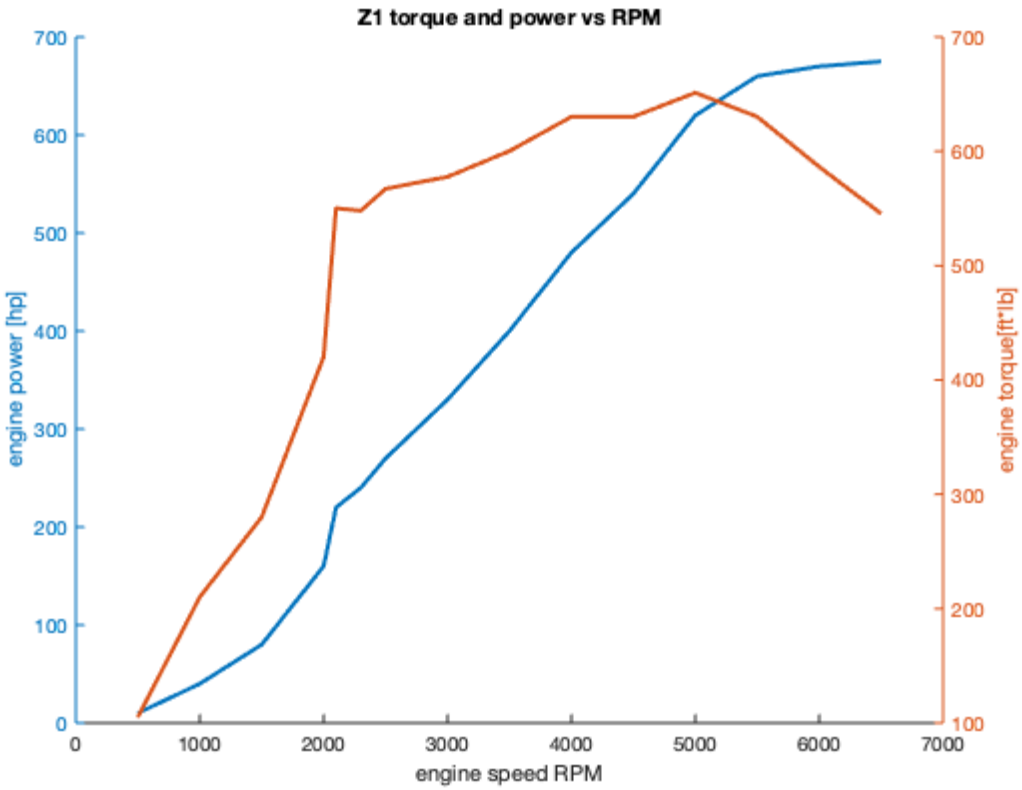
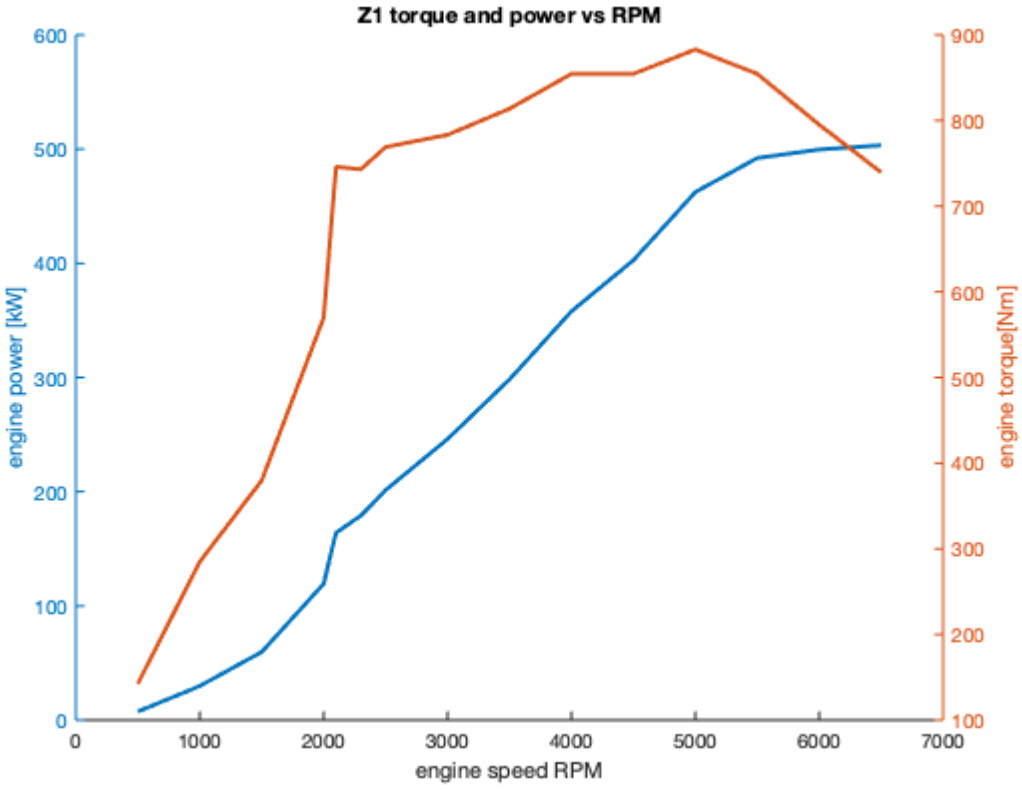
```
power_hp = [10,40,80,160,220,240,270,330,400,480,540,620,660,670,675];
speed = [500,1000,1500,2000,2100,2300,2500,3000,3500,4000,4500,5000,5500,6000,6500];
torque = (5252*power_hp)./speed;

hold on
yyaxis left
plot(speed,power_hp,'linew',2)
ylabel('engine power [hp]')
yyaxis right
plot(speed,torque,'linew',2)
ylabel('engine torque[ft*lb]')
xlabel('engine speed RPM')
title('Z1 torque and power vs RPM')
hold off
figure(2)
hold on
yyaxis left
plot(speed,power_hp*0.7457,'linew',2)
ylabel('engine power [kW]')
yyaxis right
plot(speed,torque./0.73756,'linew',2)
ylabel('engine torque[Nm]')
xlabel('engine speed RPM')
title('Z1 torque and power vs RPM')
hold off
```





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