2

HW 11: due on Tue Dec 1, in class.

Final HW :)

1) Draw a truss with at least 3 bars, more if you dare. Load it with forces as you like. Draw this neatly. Calculate the tensions in all of the bars.

2) Assume a motor following the standard motor law always operating at its peak (i.e., like an electric motor at fixed
voltage, not peak power). The transmission is lossless gear box. The motor has peak power P_p. Assume the wheels never skid. Other key numbers:

m = total mass of car (1000 kg)
P_p = 100 hp
rho = density of air (1 kg/m^3)
A = cross sectional area (2 m^2)
v = present speed of car (variable)
c_d = drag coefficient (1.0)
F_f = constan friction force (1000 N)
F_0 = force at wheel if the car is still (depends on gear ratio).
v_f = speed of car when motor supplies no torque.

The car is slowed by air drag:

Air drag = rho * A * c_d * v ^2/2.

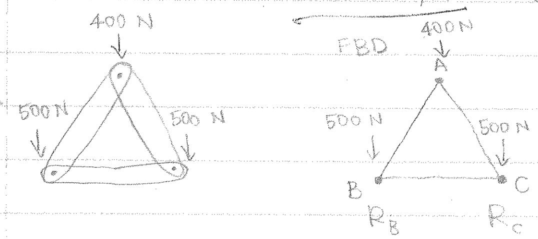
and by a constant friction force F_f.

a) Assuming the gearing is such that the stall force at the wheels is F_0 = 10,000 N (this would be the
gearing that would make the car almost skid if the friction coefficient was 1). Graph the position vs time for 20 seconds.
b) Find the fixed gear (characterized by F_0) that minimizes the time to reach 60 mph. What is that time?
c) Assume that you had a continuously variable transmission so that the P_p was always delivered to the wheels. What then would be the time to reach 60 mph? (This problem is easier than (b)).

$2+2 = 4$ $\frac{4}{10}$

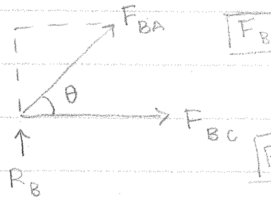
I worked with Kriston Reynolds and Michael Wodka.

1\.



find R_A, R_B first

they are not 500



F_{BA} $\sin\theta = \frac{-R_B}{F_{BA}}$ X $F_{BA} = \frac{-R_B}{\sin\theta} = \frac{-500\ N}{\sin(60)} = \frac{-500(2)}{\sqrt{3}} = \boxed{\frac{-1000}{\sqrt{3}}\ lbf}$

F_{BC} $\cos\theta = \frac{-R_B}{F_{BC}}$ X $F_{BC} = \frac{-R_B}{\cos\theta} = \frac{-500\ N}{\cos(60)} = -500(2) = \boxed{-1000\ lbf}$

$\boxed{F_{AC}} = F_{BA} = \boxed{\frac{-1000}{\sqrt{3}}\ lbf}$

$F_{drag} = \frac{1}{2} C_d A V^2$ −6

2a. $F - F_{drag} = ma$ ⇒ $\boxed{GM_o - \frac{(GM_o)^2}{4P_p} V} - \frac{1}{2} C_d A V^2 = m \frac{dV}{dt}$ −6

($C_d = 1.0$, $A = 2m^2$, $m = 1000$)

$F = GM$

$M = M_o - C\omega$

$C = \frac{M_o^2}{4P_p}$

$F_o = 10{,}000\ N$

$F = G\left(M_o - \frac{M_o^2}{4P_p}\omega\right)$ $\omega = GV$

$10000 - V^2 = 1000 \frac{dV}{dt}$

$(10000 - V^2)\, dt = 1000\, dV$

$F = GM_o - \frac{G^2 M_o^2}{4P_p} V$

$\int dt = \int \left(\frac{1000}{10000 - V^2}\right) dV$

$t = 1000 \int \frac{1}{(100)^2 - V^2} dV$

b)

$t = 1000 \cdot .005 (\ln|V+100| - \ln|V-100|)$

$t = 5 \ln\left(\frac{V+100}{V-100}\right)$

$\boxed{t = \ln\left(\frac{V+100}{V-100}\right)^5}$ X

c. $t_f = \frac{-\log\left(1 - \frac{\omega}{V} \cdot \frac{V_f}{\omega_f}\right)}{\left(\frac{\omega}{V} \cdot \frac{M_o}{m}\right)\left(\omega / \frac{V}{\omega_f}\right)}$ $G = \frac{\omega}{V}$

X

60 mph = 26.67 m/s

$\omega = \frac{\omega_f}{2} = 14.92$

$t_f = \frac{-\log\left(1 - \frac{14.92}{26.67\,m/s} \cdot \frac{26.67\,m/s}{29.84}\right)}{\left(\frac{14.92}{26.67\,m/s} \cdot \frac{10000\,N}{1000\,kg}\right)\left(\frac{\frac{14.92}{26.67\,m/s}}{28.84}\right)}$

$\boxed{t_f = 2.87\ s}$