Homework: Vehicle Models

20.1–20.6

Hayden Atchley

13 December 2023

The car I chose for this problem set is a 2005 Chevrolet Corvette C6 Z06. This is a 6-speed manual transmission car with a 427.8 in^3 V8 engine. An example of this car is shown in Figure 1.

Figure 1: A 2005 Chevrolet Corvette C6 Z06 racing at the Motor Speedway of the South in the 2005 Piston Cup final.

20.1

The following are specifications for the vehicle:

a. Final drive axle ratio: 3.42:1
b. 1^{st} gear ratio: 2.66:1
c. 6^{th} gear ratio: 0.5:1
d. Tire specification: P275/35ZR18 (front), P325/30ZR19 (rear)
e. Base curb weight: 3132 lb (13,940 N)

20.2

Given that the vehicle speed is related to engine speed as in Equation 1, where r is the tire radius and N_{ft} is the final transmission gear ratio, the vehicle cruising at 30 m/s in 6^{th} gear has an engine speed of $1539/\pi r$ m/s (the final gear ratio is $0.5 \times 3.42 = 1.71$).

$$v = \frac{\pi r}{30 N_{\text{ft}}} \omega \tag{1}$$

Since this is a rear-wheel drive car, the rear tire radius will be used for r. This is $19"/2 + 0.3 \times 325$ mm $= 0.339$ m. The engine speed is therefore $1539/0.339\pi = 1446$ rad/s.

20.3

At start-up, we are using 1^{st} gear ($N_{ft} = 9.1$) and are assuming half the maximum torque is available ($\Gamma = 317$ N-m). Since $F_e = \frac{\Gamma N_{ft} \zeta}{r}$, with $\zeta = 80\%$, $F_e = 6800$ N.

20.4

The car has a drag coefficient of 0.31 and a frontal area of 2.08 m^2, and is traveling at 100 kph = 27.8 m/s. With the density of air at 1.2 kg/m^3, the force of drag is:

$$F_d = \frac{\rho}{2} C_d A_f v^2 = \frac{1.2}{2} \times 0.31 \times 27.8^2 = 299 \text{ N}.$$

20.5

If the vehicle is traveling up a hill with a 5% grade, the grade resistance is $F_g \approx WG = 13940 \times 0.05 = 697$ N.

20.6

Assuming the vehicle is only subject to grade resistance and drag, the total force is the engine force minus the resistances ($F_t = F_e - F_d - F_g$). This force is 5805 N. The mass of the vehicle is 1421 kg, so the acceleration is $a = F_t/m = 4.1$ m/s^2.