Autonomous Vehicle PID controller for Cruise Control

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1 Finding a relation for instantaneous velocity

From Newton's Second Law:

$$\frac{d(mv)}{dt} = \sum F \tag{1}$$

For a simple model let's consider a car with thrust parameter $F_p = 30\frac{N}{\%gaspedal}$.
Now the above equation can be written as:

$$m\frac{dv(t)}{dt} = F_p u(t) - \frac{1}{2}\rho A C_d (v(t))^2 \tag{2}$$

This can be rewritten as:

$$dv(t) = \frac{F_p u(t) - \frac{1}{2}\rho A C_d (v(t))^2}{m} dt \tag{3}$$

$$\implies v(t) = \int \frac{F_p u(t) - \frac{1}{2}\rho A C_d (v(t))^2}{m} dt \tag{4}$$

where,
F_p = Thrust Parameter
$u(t)$ = Gas Pedal position (in %) at any instance of time t
ρ = Density of Air in $\frac{Kg}{m^3}$
A = Area of cross-section
C_d = coeffecient of drag
$v(t)$ = velocity at any instance of time t