

PASSING A CAR ON GA 60.

Conditions:

Passing zone = 0.5 mi = 800 m

Slow car drives at a constant speed of 45 mph = 20 m/s

Fast car is initially 0.25 mi (~400 m) behind the *slow* car

Fast car initial speed = 20 mph = 9 m/s

Fast car performance rated at 0 to 60 mph in 7 s.

1 mph = 0.447 m/s

Can the *fast* car pass the *slow* car within the passing zone?

1. The *slow* car is 400 m from the end of the passing zone. Moving at a constant speed, to reach the end of the passing zone it will take the *slow* car:

$$t_{slow} = \frac{400m}{20 \frac{m}{s}} = 20s.$$

2. Assuming the *fast* car begins its constant acceleration of $3.83 \frac{m}{s^2}$ at the beginning of the passing zone, we can solve for the time to reach the end of the passing zone:

$$\begin{aligned} x_{fast} &= v_{i,fast} t_{fast} + \frac{1}{2} a t_{fast}^2 \\ 800m &= (9 \frac{m}{s}) t_{fast} + \frac{1}{2} (3.83 \frac{m}{s^2}) t_{fast}^2 \\ 1.9 t_{fast}^2 + 9 t_{fast} - 800 &= 0 \\ t_{fast} &= \frac{-9 \pm \sqrt{9^2 - 4(1.9)(-800)}}{3.8} = 18.3s \end{aligned}$$

Since the *fast* car got to the end of the passing zone 1.7 s before the *slow* car, it can pass the *slow* car in time. However, the *fast* car's speed will be extremely high.

At what speed will the *fast* car be going at this instant?

$$v_{f,fast} = v_{i,fast} + a t_{fast} = 9 \frac{m}{s} + (3.83 \frac{m}{s^2})(18.3s) = 79 \frac{m}{s} = 177 \text{ mph} !!$$

Assume that the maximum safe driving speed = 70 mph = 31 m/s. Now can the *fast* car safely pass the *slow* car within the passing zone?

1. Time to reach top safe speed: $t_1 = \frac{31 \frac{m}{s} - 9 \frac{m}{s}}{3.83 \frac{m}{s^2}} = 5.74s$
2. Distance traveled in time t_1 : $x_1 = (9 \frac{m}{s})(5.74s) + \frac{1}{2} (3.83 \frac{m}{s^2})(5.74s)^2 = 114.8m$
3. Distance remaining to travel: $x_2 = 800m - 114.8m = 685.2m$
4. Time to travel distance x_2 : $t_2 = \frac{685.2m}{31 \frac{m}{s}} = 22.1s$
5. Total time: $t_1 + t_2 = 5.74s + 22.1s = 27.8s$

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What minimum initial separation between the *fast* and *slow* car would allow for the *fast* car to safely pass the *slow* car within the passing zone?

1. To find the minimum initial separation, let's assume the *fast* car and *slow* car get to the end of the passing zone at the same time: $t = 20\text{s}$.
2. Time for the fast car to reach top speed = 5.74 s and the distance traveled in that time is = 114.8 m.
3. $20\text{ s} - 5.74\text{ s} = 14.26\text{ s}$ = time remaining for the fast car to pass the slow car at a constant speed of 31 m/s (70 mph).
4. In that time, the fast car travels: $x = vt = (31\text{ m/s})(14.26\text{ s}) = 442.1\text{ m}$.
5. In 20 s, the fast car can travel $114.8\text{ m} + 442.1\text{ m} = 557\text{ m}$.
6. To get to the end of the passing zone in 20 s, the fast car should start at an initial position of $800\text{ m} - 557\text{ m} = 243\text{ m}$. In other words, the fast car should be 157 m ($0.097\text{ mi} \approx 500\text{ ft}$) behind the slow car when it begins to pass.