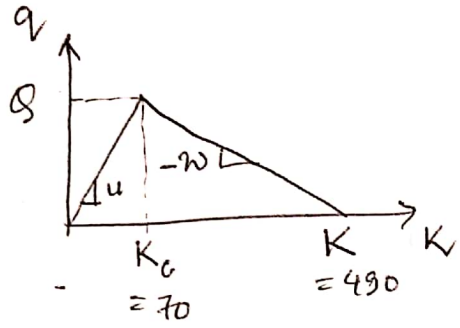
1.13.

(a)



[redacted]

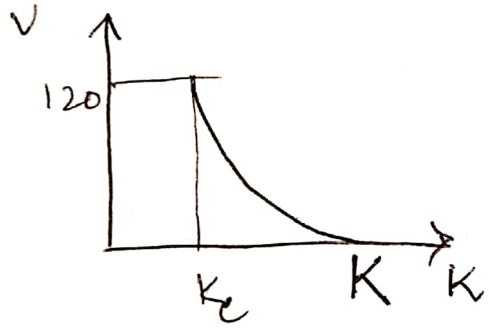
$$w = \frac{u \times K_c}{K - K_c} = 20 \text{ Km}$$

$$Q = uK_c = 8400 \text{ veh/hr}$$

$$q = \begin{cases} 120K & K \le K_c \\ Q - 20(K - K_c) & K > K_c \end{cases}$$

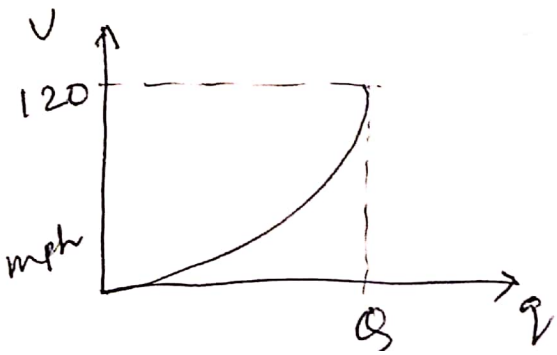
$$= \begin{cases} 120K & K \le 70 \\ 9800 - 20K & K > 70 \end{cases}$$

$$v = q/K = \begin{cases} 120 & K \le 70 \\ \frac{9800}{K} - 20 & K > 70 \end{cases}$$



$$v = \frac{9800}{q/v} - 20 \Rightarrow v = \frac{20q}{9800 - q}$$

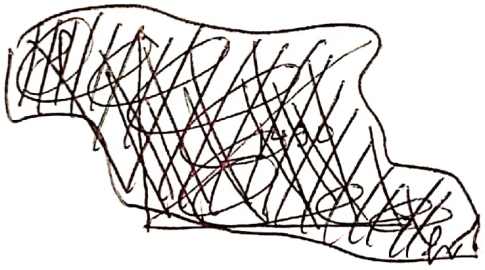
[redacted]

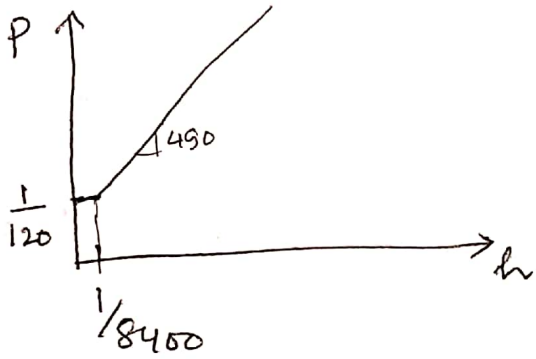


$h = \frac{1}{q}$; [redacted] $p = 1/v$

$$1/p = \frac{20/h}{9800 - 1/h} = \frac{20}{9800h - 1}$$

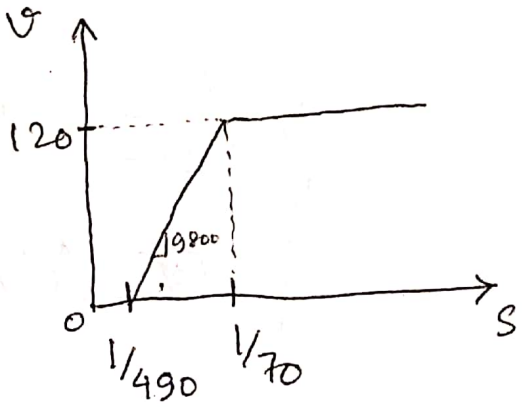
$$p = \begin{cases} 490h - 0.05 & h > \frac{1}{8400} \\ \frac{1}{120} & \text{otherwise} \end{cases}$$





$s = 1/k$

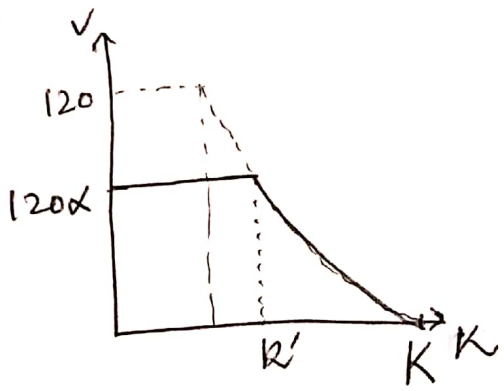
$$v = \begin{cases} 120 & s \geq \frac{1}{70} \\ 9800s - 20 & s < \frac{1}{70} \end{cases}$$



1.13.

(b) Speed limit $= \alpha u = 120\alpha$

v vs k



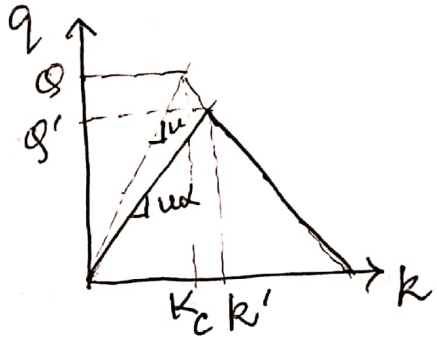
$\frac{9800}{k'} - 20 = 120\alpha$

$k' = \frac{9800}{120\alpha + 20}$

$$v = \begin{cases} 120\alpha & k \le \frac{9800}{120\alpha+20} \\ \frac{9800}{k} - 20 & k > \frac{9800}{120\alpha+20} \end{cases}$$

q vs k

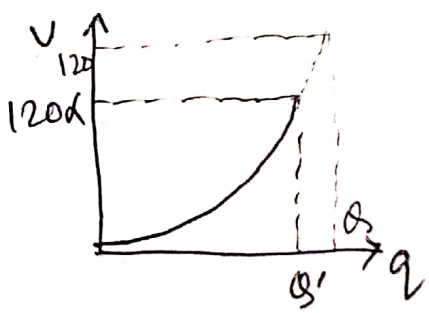
$$q = vk = \begin{cases} 120\alpha k & k \le \frac{9800}{120\alpha+20} \\ 9800 - 20k & k > \frac{9800}{120\alpha+20} \end{cases}$$



$Q' = \frac{9800 \times 120\alpha}{120\alpha + 20}$

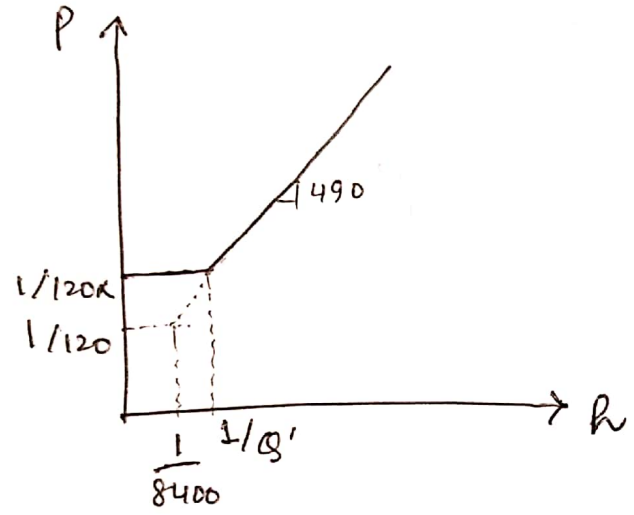
$= \frac{58800\alpha}{6\alpha + 1}$

$v = \frac{20q}{9800 - q}$; $q < Q'$

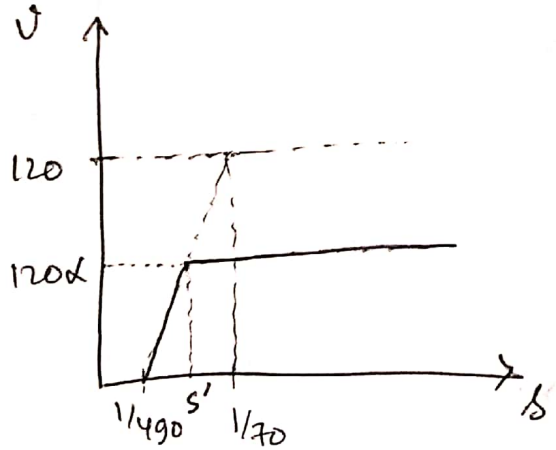


p vs h

$$p = \begin{cases} 490h - 0.05 & h > \frac{1}{qs'} \\ \frac{1}{120\alpha} & \text{otherwise} \end{cases}$$



v vs s



$$\frac{120\alpha}{(s' - \frac{1}{490})} = 9800$$

$$\Rightarrow s' = \frac{3\alpha}{245} + \frac{1}{490} = \frac{6\alpha + 1}{490}$$

$$v = \begin{cases} 120\alpha & s > s' \\ 9800s - 20 & s < s' \end{cases}$$

1.13.(c) $v = \frac{20q}{9800 - q} \Rightarrow q = \frac{9800v}{v + 20}$

Based on a sample of 10 million data points

mean = 7297 veh/hr, sd = 371 veh/hr.