Q1: While taking measurements by the moving-observer method, a test vehicle covered a 1-mi section in 1.5 min going against traffic and 2.5 min going with traffic. Given that the traffic flow was 800 veh/h and that the test vehicle passed 10 more vehicles than passed it when going with traffic, find

(a) the number of vehicles encountered by the test vehicle while moving against traffic,

(b) the speed of the traffic being measured,

(c) the concentration of the traffic stream, and

(d) whether on its run with traffic the test vehicle was traveling faster or slower than the traffic stream.

Solution: $T_a = 1.5\min$, $T_w = 2.5\min$, $q = 800\,veh/h$, $M_w = -10veh$

(a) $q = \dfrac{M_w + M_a}{T_w + T_a} = \dfrac{(-10 + M_a)veh}{(4/60)\,h} = 800\,veh/h$

solve for $M_a = 63veh$

(b) $T_{ave} = T_w - \dfrac{M_w}{q} = (2.5/60)\,h - \dfrac{-10veh}{800\,veh/h} = 0.0542h$

$$u = \frac{L}{T_{ave}} = \frac{1mi}{0.0542h} = 18.5\,mi/h$$

(c) $k = q/u = 800/18.5 = 43\,veh/mi$

(d) Faster because it passed more cars than passed it. Also,

From $\dfrac{M_w}{T_w} = q - kV_w$, one obtains,

$$V_w = \frac{q - M_w/T_w}{k} = \frac{800\ veh - \dfrac{-10\ veh}{2.5/60\ h}}{43\ veh/mi} = 24\,mi/h > 18.5\,mi/h$$

Q2: A line of traffic moving at a speed of 30 mi/h and a concentration of 50 veh/mi is stopped for 30s at a red light. Calculate

(a) the velocity and direction of the stopping wave,

(b) the length of the line of cars stopped during the 30s of red, and

(c) the number of cars stopped during the 30s of red.

Assume a jam concentration of 250 veh/mi.

Solution:

$u_a = 30\,mi/h$, $k_a = 50\,veh/mi$ and $q_a = u_a k_a = (30)(50) = 1500\,veh/h$. Also,

$u_b = 0$, $k_b = k_j = 250\,veh/mi$ and $q_b = u_b k_b = 0\,veh/h$.

(a) $u_{sw} = \dfrac{q_b - q_a}{k_b - k_a} = \dfrac{0 - 1500}{250 - 50} = -7.5\,mi/h$.

With negative value of speed, the shock wave is traveling in the upstream direction.

(b) During the 30 seconds, the shock wave traveled:

$$X = u_{sw} T = \frac{(7.5)(30)}{3600} = 0.0625 mi \ .$$

(c) Given a concentration of 250 veh/mi

$N = kX = (250)(0.0625) = 16$ vehicles were stopped.

Note: Assuming that the approach conditions were sustained, additional vehicles were stopped after the 30 seconds interval.

Q3: A vehicular stream at $q_a = 1200\,veh/h$ and $k_a = 100\,veh/mi$ is interrupted by a flag-person for 5min beginning at time $t = t_0$. At time $t = t_0 + 5$ min vehicles at the front of the stationary platoon begin to be released at $q_b = 1600\,veh/h$ and $u_b = 20\,mi/h$. Assuming that $k_j = 240\,veh/mi$,

(a) plot the location of the front of the platoon versus time and the location of the rear of the platoon versus time and

(b) plot the length of the growing platoon versus time.

Solution:

Approach conditions: $q = 1200\,veh/h$, $u = 12\,mi/h$, $k = 100\,veh/mi$

Platoon conditions: $q = 0\,veh/h$, $u = 0\,mi/h$, $k = k_j = 240\,veh/mi$

Release conditions: $q = 1600\,veh/h$, $u = 20\,mi/h$, $k = 80\,veh/mi$

Shock wave at the front of platoon:

From t= 0 to t= 5min, this shock wave remained stationary.

Beginning at t=5min, it was defined between the jam and the release conditions:

a-jam conditions, b-Release conditions.

$$U_f = \frac{q_b - q_a}{k_b - k_a} = \frac{1600 - 0}{80 - 240} = -10\,mi/h$$. (moving upstream)

Shock wave at the rear of the platoon

Beginning at t=0: b- jam conditions, a- approaching conditions.

$$U_r = \frac{q_b - q_a}{k_b - k_a} = \frac{0 - 1200}{240 - 100} = -8.57\,mi/h$$ (moving upstream)

From t=0 to t=5min.

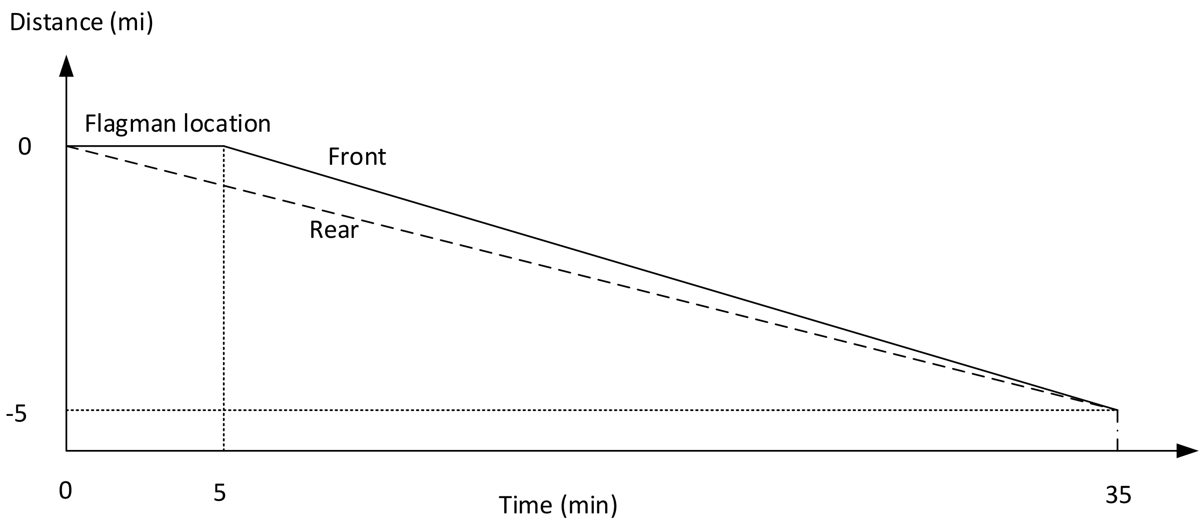
The length of platoon is $X = U_r t = 8.57(5/60) = 0.71mi$. (upstream from flagman)

After t=5min. The relative speed between the two shock waves will be 10-8.57=1.43mi/h. Given that the initial separation was 0.71mi, it will take 0.71/1.43=0.5h=30 min for the two waves to meet and for the platoon to dissipate totally.

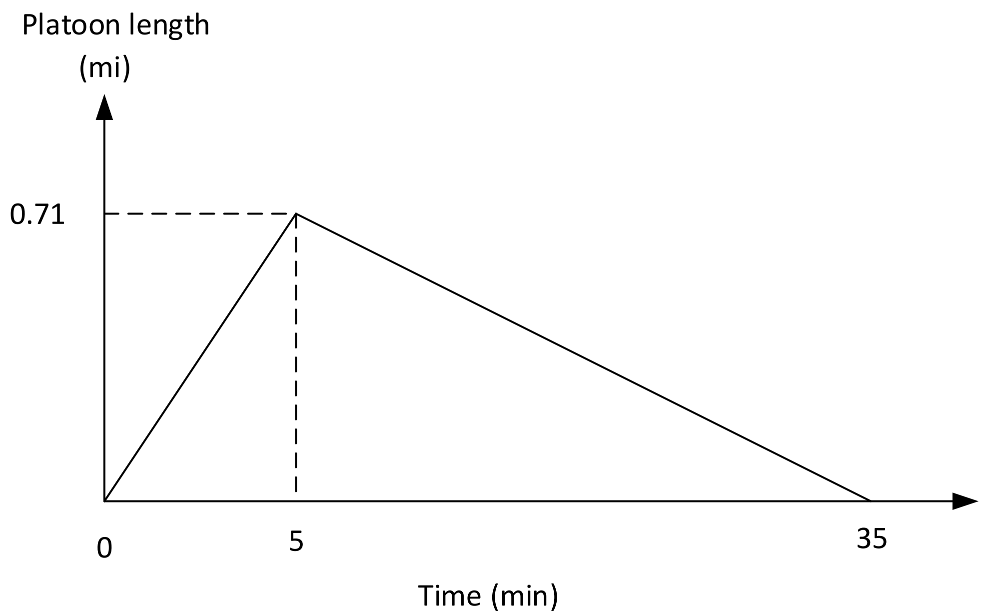
With in this 30 min, the front of the platoon moves upstream with shock wave speed U_f . The location of platoon front is

$X_{front} = U_f t = -10\,mi/h \cdot (30/60)\,h = -5mi$ at upstream from flagman location after 30min.

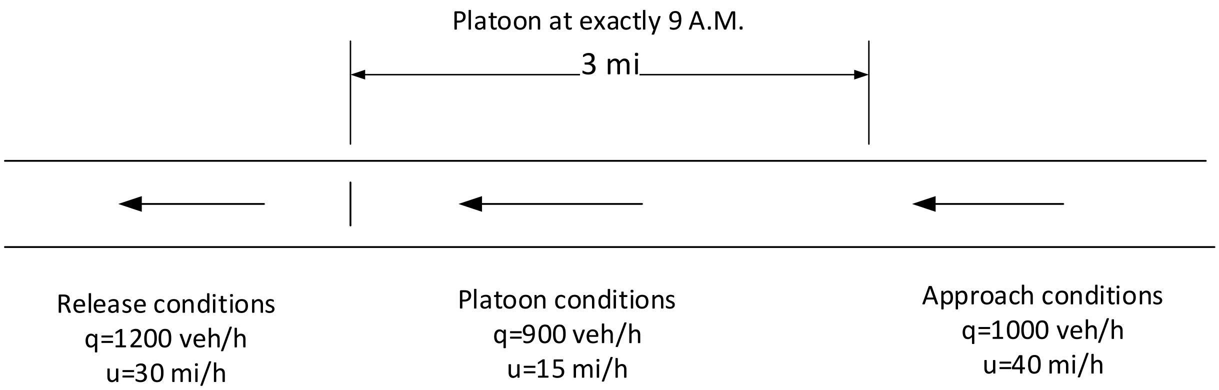
(a) Front and rear versus time:



(b) Platoon length versus time:



Q4: A 15 mi/h school zone is in effect from 7:30 to 9:00 A.M. Traffic measurements taken on October 10,1985. Showed that at precisely 9:00 A.M., the conditions presented in figure prevailed. How long did it take for the 3-mi platoon to disappear, and what was the speed of the shock wave that commenced at the moment when the platoon dissipated completely?



Solution:

Approach conditions: q=1000 veh/h, u=40 mi/h, k=25 veh/mi

Platoon conditions: q=900 veh/h, u=15 mi/h, k=60 veh/mi

Release conditions: q=1200 veh/h, u=30 mi/h, k=40 veh/mi

The shock wave that will commence at 9:00 a.m. between the platoon and the release conditions will have a speed of :

a- platoon conditions, b- release conditions

$$U_1 = \frac{q_b - q_a}{k_b - k_a} = \frac{1200 - 900}{40 - 60} = -15\, mi/h \ .$$

The shock wave at the rear of the platoon (i.e., between the approach and platoon conditions) will have a speed of:

a- Approach conditions, b- Platoon conditions

$$U_2 = \frac{q_b - q_a}{k_b - k_a} = \frac{900 - 1000}{60 - 25} = -2.86\, mi/h$$

The relative speed between the two shock waves will be 12.14 mi/h. Given that the initial separation was 3mi, it will take 3/12.14=0.25h=15 min for the two waves to meet and for the platoon to dissipate totally.

At that point, a new shock wave will commence between the approach and the release conditions. This shock wave will have a speed of:

a- Approach conditions, b- release conditions

$$U_3 = \frac{1200 - 1000}{40 - 25} = +13.3\, mi/h$$