FE Review (Transportation)

Question 1. A circular horizontal curve has a deflection angle of 39° between two tangents and radius of 600 ft. What is the length of the curve.

Solution:

Equation needs to be used:

$$L = \frac{R\Delta\pi}{180}$$

R, Δ is known, therefore,

$L = \frac{600\times39\times3.14}{180} = 408\ feet$

Question 2: A circular horizontal curve has a degree of curvature of 11° and horizontal line of sight from PC to PT of 600 ft. What is the deflection angle between the two tangents that make up the curve.

Solution. Note: horizontal line of sight (LC, called Long Cord) is not the length of the curve, it's the length the of the cord.

Equation needs to be used:

$$R = \frac{LC}{2\sin\left(\frac{\Delta}{2}\right)}$$

Degree of curvature is the angle of a 100 ft arc along the horizontal curve. For a 360° defelction angle, the curve length is 2πR. Therefore:

$$\frac{100}{D} = \frac{2\pi R}{360}$$

Which gives,

$$R = \frac{5279.58}{D}$$

Therefore:

$R = \frac{5279.58}{D} = \frac{5279.58}{11}$ =521 feet

$$Sin\left(\frac{\Delta}{2}\right) = \frac{600}{2\times521} \rightarrow \Delta = 70.3^{\circ}$$

Question 3: A circular horizontal curve has an intersection angle of 41°, a radius of 600 ft and a PI of 8+00, what is the station of PC?

Solution:

Station PC = Station PI – Tangent

$$T = R tan\frac{\Delta}{2} = 600 \tan\left(\frac{41}{2}\right) = 224.34$$

PI-224.34 = 800-224.34 = 575.66, in station, 5+76.

Question 4. Given a parabolic vertical curve with VPC station of 14+44 at elevation 792 ft, an entry grade of 2%, an exit grade of -3%, and the length of 600 ft, the elevation of the point of vertical tangency VPT is most nearly?

Solution:

Given variables: G1 = 0.02, G2 = -0.03, VPC station = 14+44 (not useful), L = 600 feet

VPT elevation = 792 + $(\frac{L}{2}\times 600)\times 0.02 - (\frac{L}{2}\times 600)\times 0.3 = 789'$

Question 5. A parabolic vertical curve on a roadway with a design speed of 75 mph has an entry grade of 7% and an exit grade of -5%. AASHTO standard driver reaction time is 2.5 seconds, and the acceleration of 11.2 ft/sec^2. For this curve, stopping sight distance criteria is based on the most restrictive slope, the minimum length of vertical curve that must be provided for these grades and stopping distance is most nearly?

Solution: Calculate minimum stopping sight distance (SSD), and according to "based on the most restrictive slope", use the downgrade in calculation to get larger SSD

SSD = $1.47vt + \frac{v^2}{30(\frac{a}{32.2}\pm G)} = 1.47 \times 75 \times 2.5 + \frac{75^2}{30(\frac{11.2}{32.2}-0.05)} = 905.5'$

Assuming SSD must be larger than curve length

$$L = \frac{ASSD^2}{2158} = \frac{(7+5)\times 905.5^2}{2158} = 4559'$$

Question 6. The pavement design for a highway segment is constructed with the following lifts and material properties: The structural number for this pavement section is mostly:

Lift	Material	Thickness (in)	Layer Coefficient (in)
Pavement	Asphalt Concrete	9"	0.44
Aggregate base	Crushed Stone	8"	0.14
Subbase	Crusher Run Gravel	12"	0.10

$$CN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3 + \cdots$$

m, which is drainage coefficient, is 1, if not given.

$$CN = 9 \times 0.44 + 8 \times 0.14 + 12 \times 0.1 = 6.28$$

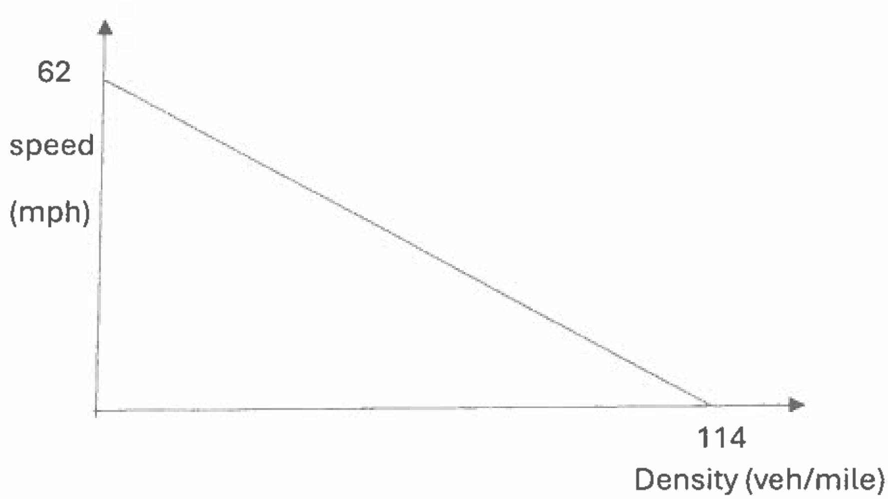
Question 7. The counts below were taken on a major arterial during the morning peak period. Based on these data, the peak hour factor is most nearly:

Time period start	Time period end	Volume (vehs)
7:00 am	7:15 am	455
7:15 am	7:30 am	658
7:30 am	7:45 am	708
7:45 am	8:00 am	728
8:00 am	8:15 am	765
8:15 am	8:30 am	744
8:30 am	8:45 am	712
8:45 am	9:00 am	618

Solution:

$$PHF = \frac{Peak\ Hour\ Volume\ (PHV)}{4 \times Peak\ 15\,\text{min}\ Volume} = \frac{728 + 765 + 744 + 712}{4 \times 765} = 0.96$$

Question 8. A plot of the mean vehicle speed versus the traffic density for a road segment is shown below, the maximum flow for this road segment is most nearly:



Solution:

62 is free flow speed, 114 is jam density.

Max volume (Capacity) = $Max\ Volume\ (Capacity) = \frac{v_f \times k_j}{4} = \frac{62 \times 114}{4} = 1767\ veh/hr$

Question 9. A six-lane freeway has an average lane width of 11 ft, and the right-side lateral clearance of 2 ft. A 2-mile stretch of freeway has 5 ramps, the FFS for this segment is most nearly:

Solution:

$$FFS = BFFS - f_{lw} - f_{RLC} - 3.22TRD^{0.84}$$

BFFS is 75.4 mph, if not given. *TRD* – is the number of ramps per mile. Get f_{lw}, and f_{RLC} from the given tables.

$$FFS = 75.4 - 1.9 - 1.6 - 3.22 \times \left(\frac{5}{2}\right)^{0.84} = 65\ mph$$

Question 10. A six-lane freeway has a peak-hour, peak-volume of 2400 veh/h in each direction with a peak hour factor of 0.96 and the free flow speed of 60 mph. The freeway is in rolling terrain, is used by regular users and is composed of 4% truck traffic, the LOS of this segment is most nearly:

Solution:

Step 1: Conver peak hour volume, which is 2400 to passenger-car equivalent volume with consideration of PHF.

$$V_p = \frac{v}{PHF \times N \times f_{HV}} = \frac{2400}{0.96 \times 3 \times f_{HV}} = 900\ veh/lane$$

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1)} = \frac{1}{1 + 0.04(3 - 1)} = 0.93$$

P_T = Proportion of tucks

E_T = Passenger-equivalent for trucks (check table in the reference handbook.)

Step 2: Find the density

$$D = \frac{V_p}{S} = \frac{900}{60} = 15\ veh/lane$$

Step 3: Check table to get LOS, which is B.

Question 11: A vehicle approaches a traffic light on a 2% upgrade at a speed of 25 mph, using a standard reaction time of 1.0 second, and the AASHTO deceleration rate of 11.2 f/s2, the minimum time allowable for the yellow signal is nearly:

Solution:

$$y = reaction\ time + \frac{v}{2a \pm 64.4G} = 1 + \frac{1.47 \times 25}{2 \times 11.2 + 64.4 \times 0.02} = 2.55\ seconds$$

Question 12: A gravity model is being used to estimate the number of trips from a business to three traffic zones. The number of trips generated by the business is estimated to be 1000 during the peak hour. Travel time, friction factor and trips produced by each zone are given in the table below, assume a social economic factor is 1.0. The trips from the business to zone 1 is:

Zone	Time	Friction	Trips Attracted
1	8	90	4000
2	12	60	4000
3	18	40	7500

Solution:

Business (1000 trips) → Zone 1(8 mins away, attracted trips = 4000)

Business (1000 trips) → Zone 1 (12 mins away, attracted trips = 4000)

Business (1000 trips) → Zone 3 (40 mins away, attracted trips = 7500)

$$T_{ij} = P_i[\frac{A_j F_{ij} K_{ij}}{\sum A_j F_{ij} K_{ij}}]$$

Zone	Time	Friction (F)	Trips Attracted (A)	$A_j \times F_{ij} \times K_{ij}$	Colum 5/Total
1	8	90	4000	360000	36/90
2	12	60	4000	240000	24/90
3	18	40	7500	300000	30/90
Total				900000	

Given social economic factor(K) = 1.0, trip generated = 1000

Therefore: T = 1000× $\left(\frac{36}{90}\right) = 400\ trips$