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OLLSCOIL na hÉIREANN , GAILLIMH

NATIONAL UNIVERSITY OF IRELAND, GALWAY

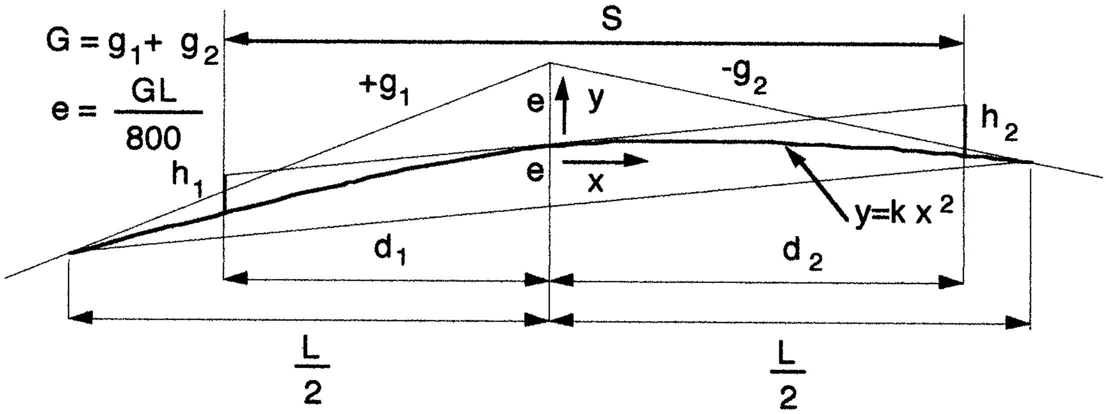
SECOND SEMESTER EXAMINATIONS, 2001

THIRD CIVIL ENGINEERING
THIRD ENVIRONMENTAL ENGINEERING

HIGHWAY AND TRAFFIC ENGINEERING 1
(CE 313)

Professor R. Falconer;
Professor P. E. O'Donoghue;
M. J. Brennan.

Time allowed: two hours.
Answer all questions.



1. A sight distance of 400 m is required on a summit curve connecting two gradients of +1% and −1%. The height of the driver's eye and the height of the opposing vehicle above the road are 1.05 m and 1.15 m, respectively.

(a) (10%) Establish which of the two formulae, S<L or S>L, is appropriate to calculate the required length of parabolic curve:

$$L(S<L)=\frac{S^2G}{100\left\{\sqrt{2h_1}+\sqrt{2h_2}\right\}^2} \text{ or } L(S>L)=2S-\frac{200\left\{\sqrt{h_1}+\sqrt{h_2}\right\}^2}{G}$$

(b) (5%) To the nearest metre, determine the minimum length of curve that is required.

(c) (5%) What sight distance is available when the heights of the driver's eye and the height of the opposing vehicle above the road are 2.0 m and 2.1 m, respectively?

Guidance: Refer to the drawing of the vertical curve and use the following formula, where h is the equivalent height of the driver's eye and the opposing vehicle to provide S/2 each side of the vertex:

$$h=\left\{\frac{\sqrt{h_1}+\sqrt{h_2}}{2}\right\}^2$$

2. (10%) The formula for calculating the minimum radius, R (m), of a horizontal curve for a design speed, V (km/h), is given by

$$R = \frac{V^2}{127(s + f)}$$

For a design speed of 120 km/h, determine the radius above which super-elevation is not required when there is adverse cross-fall of 0.025 to carry run-off water to the verges and the coefficient of friction, f, is 0.06.

3. (a) (10%) Show that the time mean speed, $\overline{u}_t$, is greater than or equal to the space mean speed, $\overline{u}_s$, given

$$\overline{u}_t = \frac{\sum q_i u_i}{\sum q_i} \text{ and } \overline{u}_s = \frac{\sum k_i u_i}{\sum k_i}$$

where q_i, k_i and u_i are the flows, densities and mid-points of the speed class intervals $(1 \le i \le n)$.

(b) (10%) The percentage distribution of vehicle speeds is tabulated below. To the nearest km/h, compute the time mean speed, the space mean speed, $\overline{u}_s$, and the standard deviation, σ_s, of the speeds u_i about the space mean speed.

Mid-point of class interval	50 km/h	60 km/h	70 km/h	80 km/h	90 km/h	100 km/h	120 km/h
% frequency	5%	10%	21%	28%	20%	13%	3%

4.

The layout, approach widths and the phasing diagram for a two-phase traffic signal controlled junction at the intersection of Seamus Quirke Road and Newcastle Road are shown on the next page. There is a separate lane for left turners on the west arm of Newcastle Road. It will have 100% green time with a separate left turning filter arrow. Note that there is a storage lane for right-turners on the east arm of Newcastle Road. So, right turners will simply have to wait here for gaps in the opposing traffic going straight ahead and turning left from the west arm of Newcastle Road.

The two inter-green times are 4 s. The amber time is 3 s and the combined starting and stopping lost times are 2 s for each phase. The saturation flow, s, is given by s (veh/h) = 520 x approach width (m). The unsaturated green time, g_u, is given by:

$$g_u = \left(\frac{gs - qc}{s - q}\right)$$

The standard formulae for calculating the signal settings are

$$c_o = \frac{1.5L + 5}{1 - Y} \quad \text{and} \quad g_i = \frac{y_i}{Y}(c_o - L)$$

The vehicular flows are tabulated below:

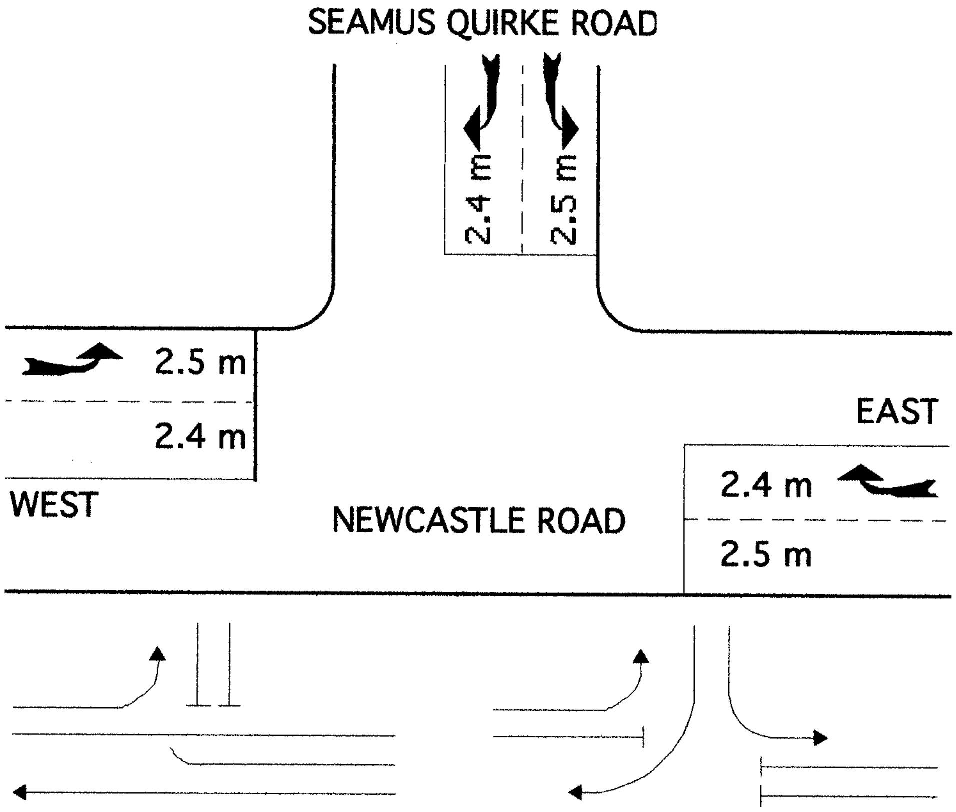
APPROACH	LANE	FLOW(veh/h)
Newcastle Road (West)	Left turning	200
	Straight ahead	405
Newcastle Road (East)	Straight ahead	625
	Right turning	220
Seamus Quirke Road	Left turning	240
	Right turning	405

(a) (10%) determine the optimum cycle time, c_o, that will minimise the total delay, to the nearest second;

(b) (5%) determine the optimum effective green times, g_i, for each traffic phase, to the nearest second;

(c) (10%) using Tanner's formula establish whether there are enough gaps in the opposing traffic (straight-ahead and left turners) on the east arm of Newcastle Road for the 90 right turners to avail of without interfering with the cross-phase. In Tanner's formula, let q_1 be 605 vehicles/h; α be 6 s; β_1 be1s; and β_2 be 2.5s. In calculating the unsaturated green time, g_u, let q be 405 vehicles/h and s be 1248 vehicles/h.

$$q_2(\max) = \frac{q_1(1-q_1\beta_1)}{e^{q_1(\alpha-\beta_1)}\left\{1-e^{-q_1\beta_2}\right\}} \qquad n_r = q_2(\max)g_u$$



5. (a) (10%) The relationship between temperature (t°C) and depth below the pavement surface (d cm) is given by:

$$t°C = \frac{d(cm)}{6} - 7$$

The relationship between suction (pF) and temperature depression below 0°C (t°C) is given by:

$$pF = 4.095 + log_{10} t°C$$

Determine the suction in <u>kN/m²</u> at the formation level below a pavement that is 37 cm thick.

(b) (5%) What would be the consequences of this for a silty sandy subgrade with a shallow water-table?

(c) (10%) With the water-table 2 m below formation level, a subgrade compressibility factor (α) of 1, and a pavement density of 2 g/cm³, what will be the suction in <u>kN/m²</u> at the formation level after the thaw.