UNIVERSITY OF BOLTON

SCHOOL OF THE BUILT ENVIRONMENT & ENGINEERING

HNC CIVIL ENGINEERING

SEMESTER ONE EXAMINATION 2009/2010

TRANSPORT ENGINEERING

MODULE NO: BLT2124

Date: Tuesday 19 January 2010 **Time: 10.00 am – 12.00 noon**

INSTRUCTIONS TO CANDIDATES:

There are FOUR questions.

Answer THREE questions.

All questions carry equal marks.

This examination paper carries a total of 60 marks.

Marks for parts of questions are shown in brackets.

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1) Vehicle speeds have been determined along a 4.0 km length of road and have been grouped into 5 km bands as shown Table One
Table One. Speed Bands

Speed km/h	Mid range km/h	Number of vehicles
35-39	37	5
40-44	42	9
45-49	47	5
50-54	52	21
55-59	57	44
60-64	62	29
65-69	67	27
70-74	72	9
75-79	77	9
80-84	82	7
85-89	87	5

a) By using this data draw a cumulative frequency graph and show how the 85^{th} and 50^{th} percentile speeds may be identified.

(8 marks)

b) Discuss the weaknesses of the data and the method used in establishing the above percentiles and suggest ways of improving the overall methodology.

(5 marks)

c) By making specific reference to *DfT Circular 01/2006* and research conducted by Finch *et al.*, 1993; and Taylor *et al.*, 2000, explain why mean speeds should now be used as the basis for determining local speed limits.

(4 marks)

d) For the majority of roads there is a consistent relationship between mean speed and 85th percentile speed. Where this is not the case, what will it usually indicate?

(3 marks)

Total 20 marks

Please turn the page

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2) A moving Observer Survey has been conducted over a 4 Km length of road and the following results were obtained.

Table Two. Moving Observer Survey.

Time in minutes and seconds	Number of Vehicles passed In opposite direction	Number of vehicles overtaking test vehicle	Number of vehicles overtaken by test vehicle.
Observer travelling northwards			
4-36	150	4	2
4-38	110	6	3
4-48	100	5	1
4-31	160	2	4
4-28	190	3	3
4-35	130	2	3
Observer travelling southwards			
4-00	200	2	2
4-10	160	2	0
4-20	220	4	1
4-20	210	2	0
4-10	170	2	1
4-30	180	4	0

Question 2 continued over the page...

Question 2 continued

a) Calculate the flow and speed in each direction ensuring that you quote the figure in the appropriate units and to an appropriate accuracy explaining how this accuracy has been derived.

(12 marks)

b) Discuss if GPS is a viable method for collecting real-time data about traffic flow and road system performance.

(8 marks)

Total 20 marks

3) The following article titled "Changes in Traffic Law May Not Drive Death From the Road" was taken from The Sunday Times – Read the article and answer the questions at the end.

Ben Webster: Analysis

With fewer people dying on the roads than at any time since records began in 1926, it may be difficult to understand why the Government is taking a harder line with those who speed or drive carelessly.

The answer may be that the measures proposed yesterday were mooted by the Department for Transport in 2004, when road deaths appeared stuck at about 3,400 a year. Since then the toll has declined to just under 3,000 in 2007 and is on course to fall below 2,700 this year.

The trend is clearly in the right direction but ministers appear determined to make more improvements and have discussed privately a target for 2020 of fewer than 2,000 deaths.

Several studies have shown that a 1 per cent reduction in average speed produces a 3 to 6 per cent fall in collisions.

The existing penalty-point system is only partly successful at making drivers slow down. Drivers who already have one three-point penalty are no less likely to be caught speeding than drivers with clean licences. But drivers with six points appear to change their ways and are only half as likely to be caught again.

The DfT says that a six-point fixed penalty for those caught at least 15mph over the limit "will effectively target excessive speeders and move them more quickly to the 6-9 point threshold, where the evidence shows they will slow down".

The question remains whether campaigning against speeding is the best way to reduce crashes.

Jim Fitzpatrick, the Road Safety Minister, said yesterday that speed was a factor in 29 per cent of fatal crashes last year, or 727 deaths.

Question 3 continued over the page...

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Question 3 continued

But a closer look at the official figures reveals that fewer than 350 of those deaths involved a breach of the speed limit. The others were caused by motorists driving within the limit but too fast for the conditions.

Such drivers will not be caught by speed cameras, only by traffic officers. The Government's proposal to make careless driving punishable by a fixed penalty may be much more effective at saving lives than issuing more points for speeding.

On the question of reducing the drink-driving limit, the Government claimed yesterday to have a "completely open mind". But last year ministers said that they were minded to reduce the limit from 80mg to 50mg, which would have put drivers at risk of prosecution after just one drink.

A study by University College London has found that a lower limit would save 60 lives a year. The DfT's road safety advertising campaigns say that motorists should not drink at all before driving. Yet the Government appears reluctant to give that message legal reinforcement.

a) By reading the above article and using evidence from other sources write a short report (500 max.) which supports the replacement of speed cameras with other alternative measures for reducing accidents.

(15 marks)

b) By using the data in Table Three below and by defining a range of performance measures present a case which shows that rail travel is the safest form of transport.

(5 marks)

Total 20 marks

Table Three shows the number of fatalities per billion km, journeys or hours of travel.

Table Three. Fatalities

Fatalities/Billion Kms	Fatalities/ Billion Journeys	Fatalities/Billion Hours Travelled
Air 0.05	Bus 4.3	Bus 11.1
Bus 0.4	Rail 20	Rail 30
Rail 0.6	Van 20	Air 30.8
Van 1.2	Car 40	Water 50
Water 2.6	Foot 40	Van 60
Car 3.1	Water 90	Car 130
Pedal cycle 44.6	Air 117	Foot 220
Foot 54.2	Pedal cycle 170	Pedal cycle 50
Motorcycle 108.9	Motorcycle 1,640	Motorcycle 4,840

4) A crossroads is controlled by traffic signals which operate on a 3 stage cycle as shown in Figure 4 overleaf. The site is level and the turning radius for right turning vehicles in stream "c" is 25 meters and for left turning vehicles in stream "d" is 12 meters. All lanes are 3.0 meters wide. Table Four shows some of the design flows and saturation flows. By assuming that the intergreen period between each stage is 5 seconds, that the amber time is 3 seconds and the start plus end lost time is 1.5 seconds you are required
to;

a) Calculate the saturation flows for streams "c" and "d".

(5 marks)

b) Calculate the optimum cycle time for the signals.

(5 marks)

c) The optimum actual green times for each stage.

(5 marks)

Table Four

Traffic Stream	Demand Flow (pcu/hr)	Percentage of turners in the stream	Saturation Flow (pcu/hr)
a	180	100	980
b	530	12	2100
c	520	100	
d	444	21	
e	100	100	1040
f	400	18	2000
g	490	100	1960
h	360	35	1850

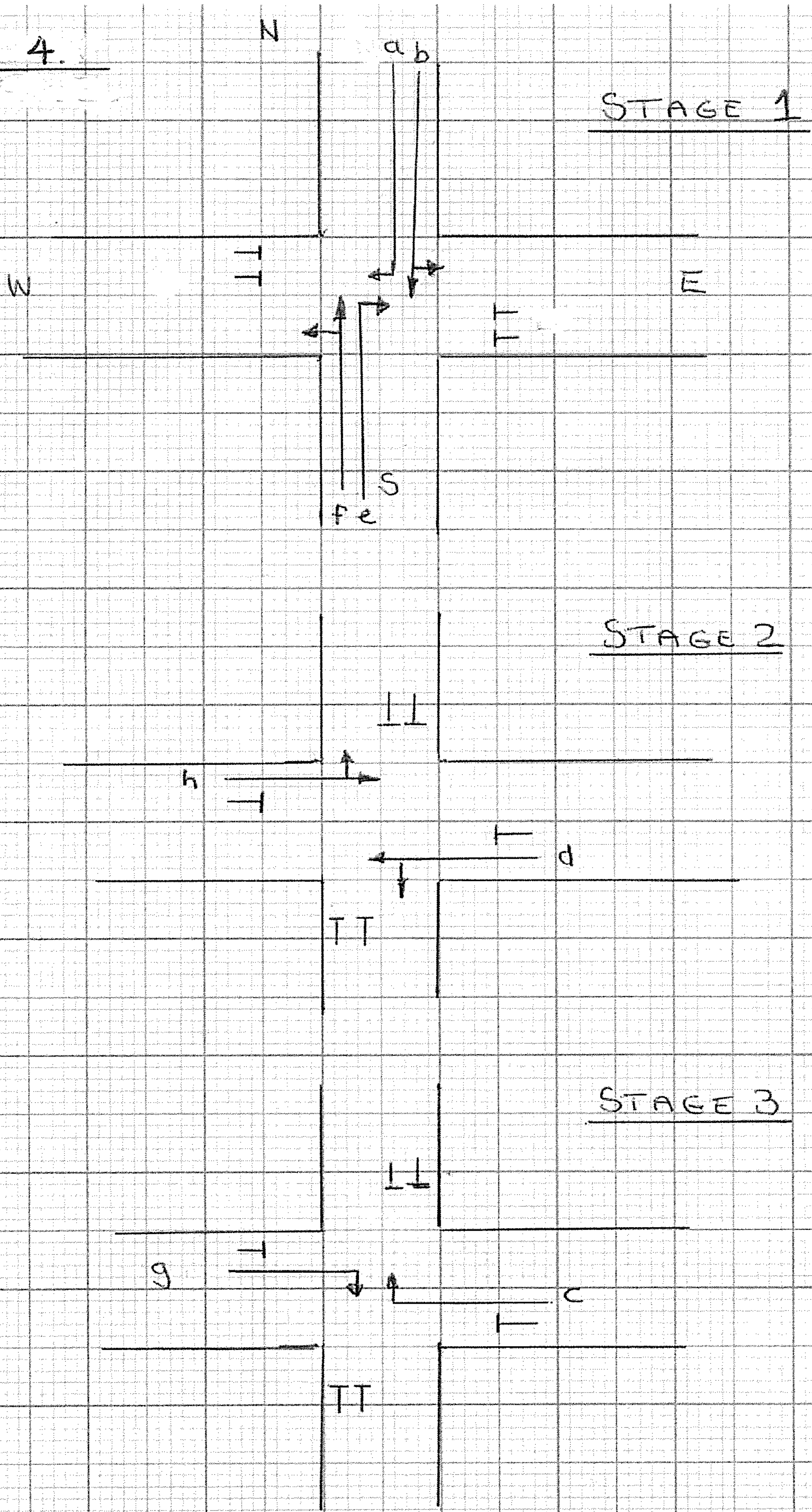
d) Discuss the features and benefits of the following two systems; i) TRANSYT, ii) OSCADY.

(5 marks)

Total 20 marks

END OF QUESTIONS

FIG 4.



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Transport Engineering and Planning
Transport Data Sheet

University of Bolton

Traffic Signal Control

$l = l_1 + l_2$; $\quad L = \sum_{stages}(I - a) + \sum_{stages} l$

$y = \frac{q}{s}$; $\quad Y = \sum_{stages} y_{max}$

$C_0 = \frac{1.5L + 5}{1 - Y}$; $\quad g'_n = \frac{y_n}{Y}(C_0 - L)$

$g_n = g'_n - a + l$

l = total lost time per stage, l_1 = starting lost time
l_2 = stopping lost time
I = intergreen, a = amber time, L = lost time per cycle
q = flow (PCU/hr)
s = saturation flow per hour (see below)
C_0 = optimum cycle time
y_{max} = largest y value for stage
g'_n = effective green time allocated for stage n
$y_n = y_{max}$ value for stage n
g_n = actual green time
g'_n = effective green time

$S_1 = (S_0 - 140\delta_n)/(1 + 1.5\frac{f}{r})$ (un-opposed flow saturation)

$S_0 = 2080 - 42\delta_g G + 100(w_l - 3.25)$

$S_2 = S_g + S_c$ (opposed flow saturation)

$S_g = (S_0 - 230)/(1 + (T - 1)f)$

$T = 1 + \frac{1.5}{r} + \frac{t_1}{t_2}$

$t_1 = 12X_0^2/(1 + 0.6(1 - f)N_s)$

$t_2 = 1 - (fX_0)^2$

$S_c = P(1 + N_s)(fX_0)^{0.2}3600/\lambda c$

$X_0 = q_0/\lambda n_l s_0$

δ_n = nearside lane dummy variable
f = proportion of turning vehicles in a lane
r = radius of curvature of vehicle path
δ_g = gradient dummy variable
G = gradient (percent)
W_l = lane width at entry (m)
N_s = number of storage spaces for right turners which do not block straight ahead movement
P = PCU factor= $1 + [P_1\%(P_1 - 1)] + [P_2\%(P_2 - 1)] + [P_3\%(P_3 - 1)] + \ldots$
λ = proportion of cycle effectively green for phase under consideration
c = cycle time
q_0 = flow on opposing arm (excluding non-hooking right turners)
n_l = number of lanes on opposing arm
s_0 = saturation flow per lane of opposing arm

$$d = \frac{c(1-\lambda)^2}{2(1-\lambda x)} + \frac{x^2}{2q(1-x)} - 0.65\left(\frac{c}{q^2}\right)^{1/3} x^{(2+5\lambda)}$$

d = delay in seconds
c = cycle time in seconds
λ = effective green time / cycle time
q = flow (converted to PCU per second)
s = saturation flow (PCU per second)
x = degree of saturation of the approach (=q / λs)

Queue Length is the larger of $qd + \frac{qr}{2}$ or qr where r is the length of effective red (c- g'_n).

Roundabout Design

$S = 1.6\frac{e - v}{l'}$; $\quad x_2 = v + \frac{e - v}{1 + 2S}$; $\quad M = e^{\left(\frac{D-60}{10}\right)}$

$t_D = 1 + \frac{0.5}{1 + M}$; $\quad F = 303x_2$; $\quad f_c = 0.210t_D(1 + 0.2x_2)$

$k = 1 - 0.00347(\phi - 30) - 0.978(\frac{1}{r} - 0.05)$

$\boxed{Q_e = k(F - f_c Q_c)}$; and

$\boxed{Q_e = k(1.11F - 1.4f_c Q_c)}$ (grade separation)

where:
e = entry width
v = approach half width
l' = average effective flare length
D = Inscribed Circle Diameter
Φ= entry angle
r = entry radius

Priority Junction Design

$q^S_{B-A} = X_1\{627 + 14W_{CR} - Y[0.364q_{A-C} + 0.144q_{A-B} + 0.229q_{C-A} + 0.520q_{C-B}]\}$

$q^S_{B-C} = X_2\{745 - Y[0.364q_{A-C} + 0.144q_{A-B}]\}$

$q^S_{C-B} = X'_2\{745 - 0.364Y[q_{A-C} + q_{A-B}]\}$

$Y = (1 - 0.0345W)$

$X_1 = (1 + 0.094(w_{B-A} - 3.65))(1 + 0.0009(V_{rB-A} - 120))(1 + 0.0006(V_{lB-A} - 150))$

$X_2 = (1 + 0.094(w_{B-C} - 3.65))(1 + 0.0009(V_{rB-C} - 120))$

$X_2' = (1 + 0.094(w_{C-B} - 3.65))(1 + 0.0009(V_{rC-B} - 120))$

where
w_{B-A} = width of minor road right turning stream as average of five measurements 0m, 5m, 10m, 15m, and 20m from the give way line for the right hand side of the approach
w_{B-C} = width of minor road left turning stream as average of five measurements 0m, 5m, 10m, 15m, and 20m from the give way line for the left hand side of the approach
w_{C-B} = width of the right turning lane from the major road, 2.1m if no specific provision
V_{rB-A} = visibility to the right for the right turning stream from the minor road
V_{lB-A} = visibility to the left for the right turning stream from the minor road
V_{rB-C} = visibility to the right for the left turning stream from the minor road
V_{rC-B} = visibility to the right for right turning traffic from the major road.
W_n = nearside major road lane width, average of widths either side of minor road
W_f = far side major lane road width, average of widths either side of minor road
W = width of major road lane widths ($W_n + W_f$)
W_{CR} = width of central reserve
q_{O-D} = flow of traffic from origin O to destination D

Moving Observer Method Formulae

$q_{a-b} = \frac{x_{a-b} + y_{a-b}}{t_{a-b} + t_{b-a}}$ $\quad \bar{t}_{a-b} = t_{a-b} - \frac{y_{a-b}}{q_{a-b}}$

Mean, SD and 85%ile estimate formula for grouped data

$\bar{y} = \frac{\sum yf}{\sum f}$ $\quad \sigma_y^2 = \frac{\sum y^2 f}{\sum f} - \frac{(\sum yf)^2}{(\sum f)^2}$ $\quad 85\%ile = \bar{y} + 1.037\sigma_y$

Coefficient of variation of a variable, X : $\quad CV_x = \frac{\sigma_x}{x}$

Combination of coefficients of variation: $\quad CV_{1,2} = \sqrt{CV_1^2 + CV_2^2}$

Variance of a product: $\quad \sigma^2(x_1.x_2) = \sigma^2_{x_1}.\sigma^2_{x_2} + x_1^2.\sigma^2_{x_2} + x_2^2.\sigma^2_{x_1}$