1.221J/11.527J/ESD.201J TRANSPORTATION SYSTEMS

FALL 2004

FINAL EXAMINATION

(30 POINTS)

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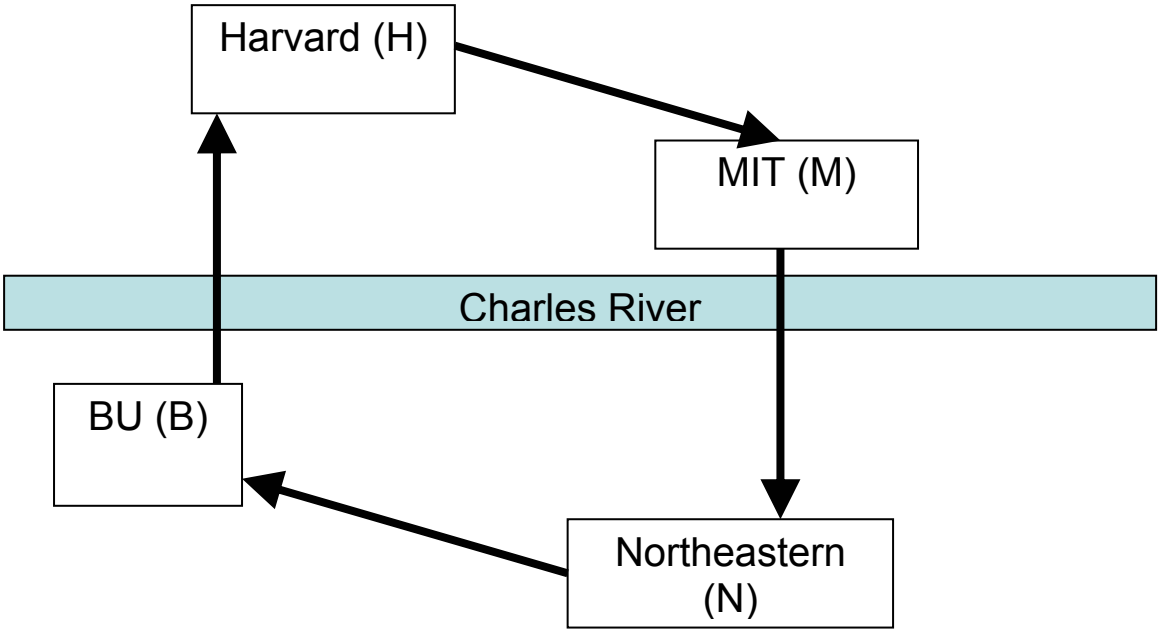
Instructions:

1. Open-book and open-notes, calculators are fine -- no laptops.
2. The exam is graded on the basis of 30 points.
3. Please read the entire exam before starting to work. Try to plan your time!

GOOD LUCK !

Problem 1: University Ring Bus System (22 points)

Four universities in the Boston/Cambridge area have decided to establish the University Ring bus system for their students and faculty to allow easy transportation among the campuses.



LOS variables for the passengers of this system are: (1) the travel time between their origin and destination universities (2) their **average** time waiting for a bus to arrive—assume that passengers arrive at random at the bus stop so that average waiting time is equal to half the headway time between buses—and (3) reliability, as measured by variability of total trip time (travel time plus actual waiting time).

a) (2 points) The universities want to provide 10 minute headways (a frequency of 6 buses per hour). A ring network is planned, going clockwise so the routing is H→M→N→B→H. Travel times are as follows:

H→M	8 minutes
M→N	6 minutes
N→B	7 minutes
B→H	9 minutes

How many buses do they need to have to provide this service? Call this **service 1**. Assume all your buses are operating (none are in for maintenance).

b) (2 points) The MIT and Harvard representatives note that travel time from M around to H is rather long and suggest that the system be designed as bi-directional (services running both clockwise and counter-clockwise). Because of the traffic patterns in the area, the travel times are not the same in both directions:

M→H	10 minutes
H→B	11 minutes
B→N	12 minutes
N→M	7 minutes

Providing 10 minute headways in both directions, how many buses do they need to have in service? Call this **service 2**.

c) MIT and Harvard are still unhappy. They argue they have the largest volumes because of cross-registration between the two schools and should have more service. They suggest that 3 of the buses be reassigned to a shuttle service that simply goes back and forth between H and M. They suggest that 1 bus be removed from the clockwise loop and 2 be removed from the counterclockwise loop; the remaining buses continue to provide bi-directional loop service. Call this **service 3** (H→M→H shuttle buses and bi-directional loops with 3 fewer buses).

i.) (2 points) What are the frequencies for N→B and B→N in service 3?

ii.) (2 points) What are the frequencies for H→M and M→H in service 3?

Note that we are now asking for **frequencies** in part (c)

d) (6 points) MIT and Harvard are unable to convince Northeastern and Boston University to dedicate 3 buses to the shuttle service. Consequently, they withdraw from the University Ring and the University Ring collapses. To replace the University Ring, MIT and Harvard decide to purchase their own buses in order to run a shuttle. Estimate how many buses MIT and Harvard have to operate in their own shuttle service so that the LOS **from** Harvard **to** MIT is **approximately** as good as it would have been if service 3 had been implemented. Consider all three LOS variables (see definitions above). Show all numerical work. Call this **service 4** (H→M→H shuttle and no University Ring).

e) (4 points) Having already withdrawn from the University Ring, MIT and Harvard reject service 4. Instead, they decide to make an arrangement with the City of

Cambridge to operate 2 shuttle buses on a special dedicated lane on Massachusetts Avenue. The travel time for these buses is as follows:

M→H 6 minutes
H→M 4 minutes

Compare the LOS between (d) and (e) for the segment **from** Harvard **to** MIT.

f) (2 points) You are the senior transportation staff member for the City of Cambridge. Assume the arrangement in (e) was political between the City of Cambridge, MIT, and Harvard, and you were not asked to approve it. The reality is that (e) will happen, but perhaps you can think of ways that the City of Cambridge can take advantage of this. Write a memo to the Mayor of Cambridge with some ideas. **There is no single right answer to this question.**

g) (2 points) Let's return to part (c). Now, you are the senior transportation staff member for the University Ring (see what good jobs taking 1.221 opens up for you ☺). Use your imagination and come up with some other ideas for how to operate this system so as to keep all the universities happy and keep the University Ring operating. **Again, there is no single right answer to this question.**

Problem 2: Transportation Funding (8 points)

Please read the following article and answer these questions.

Houston Chronicle Oct 4, 2004

"Instead of paying tax at gas pump, someday you may pay by the mile"

A major contemporary issue in highway transportation is who pays for highway infrastructure and how they pay. The traditional way is through the gas tax; drivers pay a tax when they buy gasoline which is then used to build and maintain infrastructure. This article suggests eliminating the gas tax and instead charging drivers by the mile driven.

Adopted From
Instead of Paying tax at Gas Pump, Someday you may Pay by the Mile
By Lucas Wall
October 4, 2004
Houston Chronicle

Philadelphia - Paying your road taxes in the future might depend more on how much you drive than how much gasoline you buy.

Texas is among a group of states researching how to replace the fuel tax with a fee based on the number of miles traveled. Transportation officials from across the world discussed the concept in Philadelphia at last month's annual meetings of the trade groups representing the highway and tollway industries.

Fees for miles traveled would be measured by Global Positioning System receivers embedded in vehicles. The system would track which roads a motorist uses so the virtual tolls could be distributed to the appropriate agency. Each agency could set its own per-mile fee. Data would be downloaded from vehicles monthly for billing.

Jack Lettiere, New Jersey transportation commissioner, said most states are falling short of collecting enough gas-tax revenue to meet mobility needs and they desire a new funding mechanism. "We're hoping this is a theory that can go into practice," Lettiere said at the American Association of State Highway and Transportation Officials meeting. "It has a lot of useful benefits."

Researchers love the idea that driving taxes could be adjusted to promote or discourage certain actions. The system could charge more per mile during peak hours, for instance, or add a surcharge for heavy trucks and sport utility vehicles.

Those promoting a mileage-based approach to highway taxes contend driving should be metered and billed according to use. David Forkenbrock, director of the University of Iowa Public Policy Center said that as more hybrid and alternative power vehicles are built, gas-tax collections will suffer. "A tax at the point of purchase is not as good as user charges at the exact point of travel," he said.

Oregon will test a mileage-based charge. It starts a experiment next year with 280 volunteer drivers, who will be exempt from fuel taxes in exchange for paying a per-mile tax.

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a) (3 points) Choose the three key points that you think are most relevant to this proposal. Discuss how they relate to this situation.

b) (1 point) Miles driven is approximately proportional to gasoline consumed for each driver. So what are the advantages of having drivers pay by the mile?

c) (2 points) For each of the following, suggest whether they would favor this proposal or not and why?

Ford Motor Company (Manufacturer of cars and trucks)

An individual who drives to work at usual commuting times

The operator of a commuter rail system

The chief of a state highway agency

d) (2 points) The last paragraph of the article refers to an experiment in Oregon where 280 drivers "will be exempt from fuel taxes in exchange for paying a per-mile tax". If you were in charge of this experiment, what hypotheses would you be interested in testing? How would you test them (i.e., what would you measure)?