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

FALL 2003

FINAL EXAMINATION

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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 !

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(30 points)

QUESTION 1A (12 points)

This question asks you to analyze a proposed direct-link bus route between MIT and Harvard University.

Background Information

The administrators of Harvard University and MIT are deciding whether to provide a dedicated, non-stop bus service between Harvard Yard and 77 Massachusetts Avenue (MIT) in order to make commuting easier for those students who choose to cross-register for coursework between the two schools.

Some of the issues that the administrators must decide upon include:

A. The fare to be charged to the MIT and Harvard students and staff for riding the bus (if any).
B. Whether to allow people who are **not** MIT and Harvard students and staff to use the service, and if so, at what fare?
C. The size of the bus fleet.
D. Whether to subsidize the operation of the buses through the use of tuition money.

The travel time for the bus from Harvard to MIT is 10 minutes. The travel time for the bus from MIT to Harvard is 12 minutes. The bus remains at each terminus for 4 minutes. Assume that if a passenger is at the bus stop, he will be able to board the bus -- i.e. the bus will be able to fulfill all demand.

The service will be paid for by fares or by a rise in tuition. The cost to operate one bus per day is $200.00.

The overall demand for the MIT-Harvard bus service is given by the following equation:

$$D = 100 * \frac{[1 + FREQ - FARE]}{FARE} + DUMMY * \frac{[8 + FREQ - BFARE]}{BFARE}$$

Where:

D = Total Daily Demand (One Way Trips)

FREQ = Bus Frequency per Hour

FARE = Price Charged to Students and Staff to Ride the Bus (One Way Trips)

BFARE = Price Charged to people not affiliated with MIT or Harvard to Ride the Bus (One Way Trips)

DUMMY = Variable which is set to **5** if people not affiliated with MIT or Harvard are permitted to ride and **0** if not.

Scheduling

1. If the schools purchase and use a total of three buses, what is the headway they can provide? What is the per-hour frequency they can provide? (2 points)

Fares

1. Assume only students and staff are permitted to use the bus service. Call this **OPTION 1**. If the schools decide to make the students and staff pay for the service, what fare should be charged to each rider for a one-way trip in order for the service to break even? Assume three buses are operated and no subsidy is provided from tuition money. (2 points)

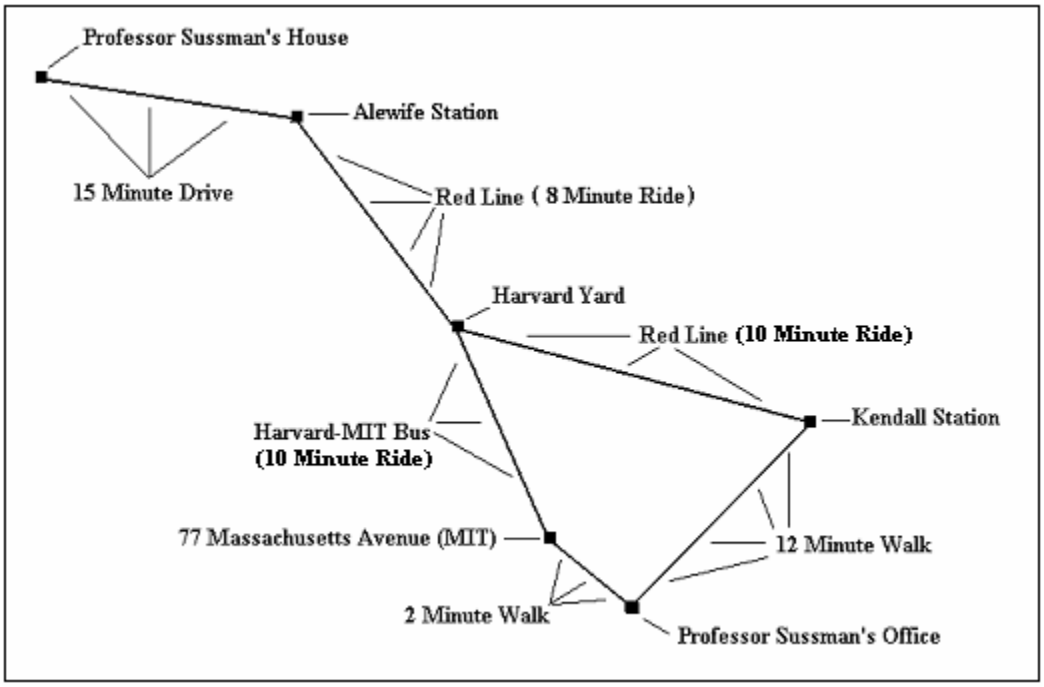
2. Suppose the schools decide to charge the students and staff a $0.50 fare. Furthermore, other people who are not affiliated with MIT or Harvard are allowed to ride the bus. Call this **OPTION 2.** One additional stop is added to the route in each direction. The bus stops at that stop for 3 minutes in each direction (for an extra 6 minutes of time on the route). How much should be charged to the non-students for riding the bus in order for the service to break even? Again, assume three buses are operated and no subsidy is provided from tuition money. (4 points)

3. Qualitatively discuss how the City Council of Cambridge would react to the proposal for bus service between Harvard and MIT under OPTION 1 and under OPTION 2. (2 points)

4. Qualitatively discuss how the MBTA would react to this proposal under OPTION 1 and under OPTION 2. (2 points)

QUESTION 1B (8 points)

Suppose the MIT and Harvard administrators decide on a zero-fare bus service that can be used by **both** students and staff. Other people who are not affiliated with MIT or Harvard are not permitted to ride. Professor Sussman lives a 15-minute drive from Alewife Station. After hearing about the new free bus link between Harvard and MIT, Professor Sussman (who is always interested in a free ride!) needs to decide whether to change his pattern of commuting to work. Currently, he drives from home, parks at Alewife Station and walks downstairs to the train. This all takes 15 minutes. From there, he boards the train and rides it to Kendall Station. The headway on the Red Line is 4 minutes. Then, there is a 12-minute walk from Kendall Station to his office in Building 1 at MIT. Professor Sussman must decide whether it is now preferable to drive to Alewife Station, ride the MBTA to Harvard Station, walk to the street which takes 1 minute and transfer to the new direct-link bus route, and then walk to his office from 77 Massachusetts Avenue. The walk to the office would be only 2 minutes instead of the 12 minutes he had to walk from Kendall Station to his office. However, he will have to wait at Harvard for the bus.



Assume for this question that the headway for the MIT to Harvard bus is actually 14 minutes (not the headway you calculated in question 1A). Furthermore, assume that the time to travel from Harvard to Kendall on the Red Line and the time to travel from Harvard to 77 Massachusetts Avenue on the bus are both 10 minutes (not including any wait time). It takes 8 minutes to travel from Alewife to Harvard on the Red Line (also not including wait time).

1. Identify Professor Sussman's level of service (LOS) variables for his journey to work. (2 points)

2. Compute the expected travel time by both travel options. (1 point)

3. Which travel option is more reliable? Why? (2 points)

4. When Prof. Sussman selects a travel option, might his decision be related to the day of the week? Why? Might his decision be related to the time of year? Why? (1 point)

5. The administrators decide to offer no-fare bus service for staff and students. The costs of the service will be recovered by raising tuition. Non-students will not be allowed to ride the bus. The MIT campus newspaper, *The Tech*, has asked you to write an editorial about the new service. Please write the editorial. Limit your editorial to 1/2 page in your exam booklet. (2 points)

QUESTION 2 (10 points)

Please read the following (edited) article, "A Win-Win Situation for Our Freeways: High-Occupancy Toll Lane Systems Ease Traffic While Raising Revenue", and respond to the questions below.

- Discuss the article from the perspective of the 2 Key Points you think are most important. (2 points)
- List 4 customers for this concept and what they would find valuable about it. (2 points)
- List 4 stakeholders and their likely opinion of this concept. (2 points)
- The article is an opinion piece, meant to advocate a particular point of view about this concept. The author is clearly positive. Choose one of your stakeholders with a negative viewpoint and write a short article (less than one page in your exam book) explaining that viewpoint. (4 points)

A Win-Win Situation for Our Freeways: High-Occupancy Toll Lane Systems Ease Traffic While Raising Revenue

(modified from "A Win-Win Situation for Our Freeways: High-Occupancy Toll Lane Systems Ease Traffic While Raising Revenue", by Robert W. Poole, Jr., *The Los Angeles Daily News*, August 29, 2003)

California's bad financial condition means many transportation projects have been postponed. So, Southern California's traffic woes will only get worse. As a result, it's time for us to consider new answers to Los Angeles' gridlock. Southern California's freeways could be altered to improve public transportation, guarantee every driver a congestion-free alternative, and create a much-needed source of revenue for road projects.

By changing existing and planned carpool lanes into a network of variable-priced toll lanes, we could guarantee drivers and buses at least one lane moving at the maximum speed limit, at all times, on most Los Angeles freeways. Buses and high-capacity vans would use the lanes free of charge, speeding up their trip times and boosting their appeal and effectiveness. Individual motorists would pay a variable toll that would be paid electronically, using FasTrak transponders attached to a car's windshield, thus eliminating the need and expense of tollbooths and cash transactions.

The number of vehicles in the variable-priced toll lanes would be controlled through pricing policy, with rates highest during rush hour, ensuring the lanes are always moving at 65 miles per hour and providing transportation agencies with a significant source of income for construction and maintenance projects.

A busy Friday afternoon at rush hour would yield some of the highest toll rates -- perhaps as high as 40 cents per mile during peak times. That sounds expensive, but consider this: Someone leaving California State University, Northridge, to catch a flight at Los Angeles International Airport could cruise along at 65 miles per hour (on a Friday afternoon) in the toll lane of the 405 Freeway and arrive at the airport in 30 to 35 minutes. Most business people, and countless others, would deem the 90 minutes saved well worth the $8 toll paid. Some businesses and commuters would choose to use the lanes every day. Most of us would choose to use the lanes when we have to get to a meeting or a child's soccer game on time.

A detailed analysis by the Reason Foundation and several scholars shows that Los Angeles would benefit from these lanes more than any other city in the country. Toll revenues would exceed $922 million per year -- that's nearly $1 billion each year that could be used to reduce congestion on our roadways.

Everyone in Southern California would win with high-occupancy toll (HOT) networks. Individual drivers get the option of faster, more reliable travel when saving time is very important. Public transit riders get a region-wide express bus service that is likely to see increased ridership because of its higher speeds and more reliable performance. Taxpayers win because they get a major improvement of the transportation system without the need for new taxes. Even drivers who never use the lanes benefit from less congestion in the regular lanes.

The cost of building a network of new lanes and interchanges and modifying current lanes, would total $10.8 billion -- which seems extreme, particularly amid the California budget deficit. However, since the projected toll revenues are so substantial ($922 million each year), revenue bonds, at no taxpayer expense, would be able to cover 86 percent of the costs necessary to create a seamless network of HOT lanes. The rest of the funding, just 14 percent, would come from traditional federal and state transportation programs.

Southern California has a choice: We can continue to watch our highways become more congested and spend tax dollars on transportation projects, like rail systems, that do nothing to improve our commute times, or we can turn part of our freeways into a revenue-producing network that offers excellent express bus service while also guaranteeing each driver a free-flowing lane for those days that we absolutely have to get somewhere on time.