NET 2025 Power Round: Solutions

Introductory Division

April 2025

Instructions

This test consists of six questions. While you are free to attempt all six questions, we will only grade your four best-performing questions, regardless of how well you do on the other two. A question's point value is *not* informative of its difficulty; although questions have different point values, each question is weighted independently of its point value in your final cumulative score. After normalizing point-values of each question to the same weight, your cumulative score will be calculated as the sum of the scores of your four best-performing questions. You are encouraged to work together on these questions. Answer each question as clearly and succinctly as possible. You may write on a blank sheet of paper where you *clearly indicate* where your answer to each part is. If you are unsure of your answer, take your best guess: there is no penalty for incorrect answers. If you find yourself stuck on a question, skip it and return to it at the end if necessary. You will have two hours (120 minutes) to complete the exam. Remember, we do *not* share your answers or scores with Northwestern admissions, nor do we keep them for ourselves. You are not expected to know how to answer each question on the exam; rather, this test is designed to assess your economic and formal reasoning skills. Have fun, and good luck!

Problem 1: Governing the Debt (20 Points)

This question considers how government expenditure impacts otherwise efficient markets both through expenditure and fundraising.

In a closed economy, the short-run aggregate supply is fixed at $P = 1$. Consumption is given by:

$$C = C_0 + 0.6(Y - T), \tag{1}$$

where C_0 is autonomous consumption, $Y - T$ is disposable income (total income minus net taxes).

Investment is given by:

$$I = 12 - 5r, \tag{2}$$

where r is the real interest rate expressed as a percentage (e.g., $r = 1$ means 1%, not 100%). The supply of loanable funds is:

$$S = 14r. \tag{3}$$

The budget is balanced at $G = 20$, so government spending is equal to taxes.

The economy is balanced when:

$$Y = C + I + G. \tag{4}$$

Part A

(1) *(1 point)* Intuitively explain why investment decreases and the supply of loanable funds increases as the interest rate increases? As the interest rate increases, there is greater incentive to lend money as the opportunity cost of holding money increases. The required return for investments to be profitable also increases and fewer investment opportunities are utilized. 1 point for similar explanation for both supply and demand (investment) for loanable funds

(2) *(1 point)* Which component of consumption depends on disposable income and which does not? What could be some expenditures that do not depend on disposable income? Autonomous consumption does not depend on income, 0.6(Y-T) does. Rent or toothpaste could be an examples of consumption not dependent on income. 0.5 points for explanation, 0.5 points for example

(3) *(1 point)* What should the value of taxes be if the budget is balanced? 1 point for 20, no points for equal to G as this is stated in the question text

(4) *(2 points)* What does the coefficient of disposable income (0.6) represent in this case?
Tip: Think about how consumption changes when disposable income increases by 1. What choices do consumers have when they receive an additional dollar of disposable income? 2 points for Marginal Propensity to Consume or other explanation that correctly identifies that consumers spend 0.6 dollars for every additional dollar of disposable income

Part B

(1) *(3 points)* In the balanced economy at $Y = 100$, determine the levels of C, I, T, and r. r = 12/19 = 0.63, G = T = 20, C = 71.16, I = 8.84, partial credit possible if adequate reasoning is shown

(2) *(1 point)* Now, the government wants to increase economic growth, so it decides to increase government spending by 10. Assuming that the government has this money at its disposal and does not need to finance this spending through taxes or investment, what is the change in Y? Y=125

(3) *(1 point)* Assume that the government wants to cut taxes by 10 instead. What is the new level of income? Y=115

(4) *(2 points)* Why do the two above options create different levels of final income if the government uses the same 10 at its disposal in both situations? It is because the spending and tax multipliers are different. When the government spends 10 dollars, it is a direct injection of 10 dollars to start the multiplier process. But when the cuts taxes, the initial impact is 6 dollars as 4 dollars is saved, then, the effect is also 5/3rds the effect of increase in spend. (Answers breaking down the effect into consumption etc. will not be accepted as this is the result and not the cause.)

(5) *(3 points)* Now, suppose the government wants to increase G by 10 but has to fund this spending through taxation. What is the new level of Y? Y = 110

(6) *(3 points)* What if the government decides to fund this spending in the loanable funds market by borrowing 10?
Tip: How does this change the demand for loanable funds? What made up the demand for loanable funds before? (New r = 22/19 (1 point), Y=118.42 (2 points)

(7) *(2 points)* Let us consider the intermediate case where the government borrows 5 on the market and funds the additional 5 through taxes. Is the increase in Y higher this way? Which of the three options (borrow all, tax all, borrow some and tax some) would a policymaker choose? Borrowing all is best for the economy in the scope of this model. (Comments about long-term debt are disregarded.)

Problem 2: When Work Doesn't Work (21 Points)

This question considers two types of unemployment and their theoretical underpinnings. It also demonstrates some features of a minimum wage. In an economy, L is the number of those in the labor force, U is the number of unemployed, and E is the number of those employed.

Frictional Unemployment

(a) *(1 point)* If s is the job separation rate of those who are employed, express the number of people who are separated from their jobs each month in terms of s and E. (i.e. if $s = 0.1$, 10% of those employed quit/lose their jobs every month) sE

(b) *(1 point)* If f is the job finding rate of those who are unemployed, express the number of unemployed who find jobs each month in terms of f and s? fU, question states wrong variables, all teams awarded points

(c) *(2 points)* What is the condition for the number of employed and unemployed persons to remain the same? (Tip: What happens if more people find jobs than are fired?) sE=fU

(d) *(2 points)* Using this condition, derive the equation for the unemployment rate, U/L in equilibrium, in terms of s and f. (Tip: what is E in terms of L and U?) s(L-U) = fU $\rightarrow \frac{L}{U} - 1 = f/s \rightarrow L/U = (f+s)/s \rightarrow U/L = s/(s+f)$

(e) *(2 points)* What is the cause of unemployment in this case, what values of s or f would provide a long-term unemployment rate of 0? The time it takes employees to find jobs and job seperation cause unemployment in this model. (1 point) No unemployment conditions: (2 points) s=0 or f $\rightarrow \infty$

Structural Unemployment

In an economy, the demand for labor is given by $D = 100 - 2w$, and the supply of labor is given by $S = 8w$, where w is real wage.

(a) *(3 points)* In equilibrium, what is the wage rate, unemployment rate, and the number of unemployed? 1 point each, w=10, U=20, unemployment is 20 percent

(b) *(3 points)* Now, assume that the government imposes a minimum wage of $w = 30$, what is the new unemployment rate? 5/6

(c) *(1 point)* What does this suggest about the minimum wage? A minimum wage above the market wage leads to unemployment

What about demand?

(a) *(1 point)* Do low-income earners or high-income earners have a higher marginal propensity to consume (MPC)? Low-income earners

(b) *(3 points)* So, does overall MPC increase or decrease with a higher minimum wage? Note that minimum wage increases the income level of the lowest-income earners. Increases as more income goes to people with a high marginal propensity to save

(c) *(2 points)* If labor demand depends positively on income, explain how an increase in the minimum wage could increase employment. It could increase aggregate income due to a higher overall MPC in the economy, thus labor demand, leading to a higher level of employment in the economy (if interpreted as income = wage, this is wrong)

Problem 3: Imperially Empirical (20 Points)

This text considers the research related to the 2024 Nobel Prize in Economics. It attempts to show the empirical difficulties with economics research and some tools we use to circumvent them.

Part A *(3 points)* A long term conversation in development economics is whether geography or institutions are more important to a country's development. What geographic factors contribute to economic growth? Why might these factors not be so important? 2 points for reasonable description of geographic factors (inc. resources, water routes, coal/oil, land farmability/constructibility, proximity to rich countries), 1 point for discussing how resource rich countries are often poor, or other conversation of utilization.

Part B *(2 point)* Some economists asserts that institutions are more important than geography. How might we estimate the strength of institutions? 1 point for reasonable answer (inc. number of lawyers, size of government, corruption, expropriation, other indexes) and 1 point for a discussion of it.

Part C *(1 point)* Let us call institutional strength the variable I. Suppose you find that a 10% increase in I in a given year in a given country correlates with a 20% increase in the country's GDP per capita the following year in the same country. Without considering statistical significance, give three explanations for this result. (Hint: many explanations can be true at the same time.) 1 point for complete answer, but partial credit available. Some answers include: richness creates stability, disasters can destroy both, large institutions require stability, wars impact both but inconsistently. You may also discuss the value of strong institutions.

Part D *(2 point)* Suppose you get the result shown below. Note that p represents place. We will use y to mean the per capita GDP of a country. This means that y_p represents the GDP per capita in a given year at a given place and y_{France} represents the GDP per capita of France in a given year. The variable ϵ, called the error term, represents everything not determined by p such that $\epsilon_p + I_p$ can estimate the value of y_p for a place with similar characteristics to p but differently strong institutions. What is an effect of a 1 unit increase in I on y_p?

$$y_p = 2 * I_p + \epsilon_p$$

1 point for correct equation, 1 point for recognizing that its 2.

We can represent this as the change in y_p divided by the change in I_p

Part E *(3 point)* Why is this not sufficient as a causal argument? Give three examples. May refer back to problem C. 1 point for each example and an adequate understanding for confounding variables, even without naming them.

Part F *(3 point)* In a study of growth in Africa, some economists suggests we can use settler mortality in a region to estimate institutions' strength. Explain why economists might be more interested in using settler mortality than institutional strength. 1 points for any discussion. 1 point for recognizing that causal disconnect between settlers and modern growth. 1 point for showing causal pathway. Generous partial credit awarded if the response shows how this solves problems mentioned in Part E (or doesn't).

Part G *(2 point)* Suppose we run some tests and find the effect for settler mortality, denoted

M, influencing institution strength can be modeled by equation

$$I_p = 3 * M_p + \epsilon_p$$

And we find the equation for settler mortality influencing GDP per capita can be modeled by

$$y_p = 2 * M_p + \epsilon_p$$

Estimate the effect of a 1 unit increase in institution strength on the GDP per capita of a country assuming that the average error term is 0 and it is evenly distributed. (Hint: Consider part 4) 1 point for correct equation. 1 point for correct answer. Correct answer is I/M = 3 and y/M = 2 so y/I = 2/3

Part H *(4 point)* Compare your result to part 4. Why might your results be different? Which methodology provides the best evidence of a causal relationship? Explain your answer. New result is smaller. These results are different because we're now estimating the effect through an instrument and correcting for confounding variables. This result is smaller because in this hypothetical the confounding variables were positive. This is better evidence of a causal relationship since we correct for time dependency and many other confounding variables. 1 point for understanding the difference, 1 point for understanding the source of the differences, 2 points for a good discussion of why this methodology improves causal inference and what flaws it may still have

Problem 4: Indifference Curves (20 points)

This problem explores indifference curves, which show the relationship between the relative value of two goods.

Preliminaries A consumer has an income, denoted M, of 100. The price of one apple is set at The price of one apple is set at $5. Let A represent the quantity of apples purchased by a consumer. The price of one banana is set at $10. Let B represent the quantity of bananas purchased by a consumer.

A utility function shows how much satisfaction a person gets from different bundles of goods, and an indifference curve represents all the combinations that give the same satisfaction level. The consumer's utility function is $U(A, B) = A^2B^3$.

Part A *(1 point)* Write down an expression that shows how many apples and/or bananas a person can purchase if they append their entire income on only these two goods.

1 point for the correct equation $5A + 10B = 100$

Part B *(1 point)* Would it be ideal for the consumer to purchase only apples or only bananas? Justify using the given consumer utility function. No, it would not be ideal because if A = 0 or B = 0, the utility function will yield a final value of zero. 1 point for responding no with a correct justification.

Part C *(3 points)* Compute the utility for each of the following bundles and determine which one maximizes the satisfaction of the consumer:

a) (A = 8, B = 6) 13824. 1 point for the correct number

b) (A = 6, B = 7) 12348. 1 point for the correct number

c) (A = 10, B = 5) 12500. 1 point for the correct number and identifying this bundle as the one with maxin

Part D *(4 points)* The consumer is currently choosing (A=6, B=4) and is considering moving to (A=8, B=3).

- (2 points) Compute the change in utility

Current Utility = 2304
New Utility = 1728
Change in utility = 1728 - 2304 = -576
1 point for calculating the correct current utility and new utility.
1 point for calculating the correct change in utility.

- (2 points) Does this change increase or decrease their overall satisfaction? Justify your answer.

The change in utility is negative, so the overall consumer satisfaction decreases.
1 point for indicating there is a decrease in customer's overall satisfaction. 1 for point for any correct justifaction.

Part E *(2 points)* In a different scenario, suppose a consumer's optimal bundle consists of 12 apples (A) and 9 bananas (B), which uses up their entire income of $198. The consumer found that the best ratio of apples to bananas was

$$\frac{A}{B} = \frac{12}{9} = \frac{4}{3}$$

based on their utility function, regardless of their income. Now, assume the consumer's income decreases by one-third due to an economic downturn. If the prices of apples and bananas remain unchanged, use the given ratio to determine how many apples and bananas the consumer would purchase while staying within their new budget.

Income decreases by $\frac{1}{3}$, so the number of products that the consumer purchases also decreases by $\frac{1}{3}$.

$$\frac{2}{3}(12A + 9B) = 8A + 6B$$

Keeping the same ratio, the consumer will purchase 8 apples and 6 bananas. 1 point for the correct calculation process (partial marks are given for having a correct start). 1 point for the correct final answer.

Part F *(5 points)* Initially, the consumer intended to purchase (A=8, B=6) bundles of apples and bananas. However, due to limited stock, the store only had 4 bananas available for sale. As a result, the consumer had to adjust their purchase to (A=12, B= 4) bundle.

To compensate for the unavailability of bananas, the store offered one additional apple to the consumer for free, leading to a final bundle of (A=13, B=4) bundle.

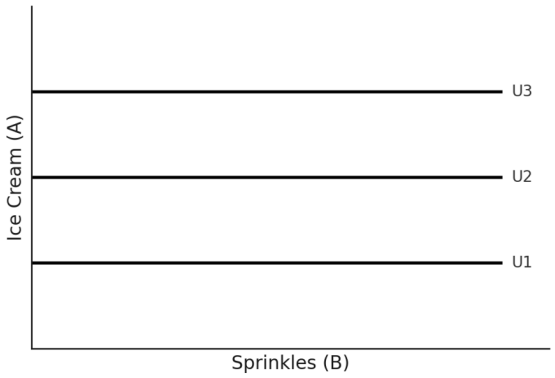
- *(2 points)* Compared to the original intended bundle (A=8, B=6), does the compensated bundle (A=13, B=4) provide greater, equal, or lower satisfaction for the consumer?

  Original bundle (A=8, B=6) has utility 13824.
  Compensated bundle (A=13, B=4) has utility 10816.
  The compensated bundle provided lower satisfaction.
  1 point for getting the utility of the original and compensated bundle correctly. 1 point for indicating the compensated bundle provides lower satisfaction for the consumer.

- *(3 points)* What is the minimum number of apples the store must provide to ensure the consumer is at least as satisfied as they would have been with their original intended bundle? (Answer in whole numbers.) How would you know that the consumer is just as satisfied or slightly more satisfied?

  Let x represent A, which is the number of apples, and let B represent the number of bananas.
  $x^2 \cdot 4^3 = 13824 \rightarrow x^2 = \frac{13824}{64} \rightarrow x \approx 14.7$
  Since only whole numbers count, round up.
  $A = 15$, $B = 4$ The store must provide at least 15 apples in total (or 3 additional apples). The consumer is slightly more satisfied. 2 points for having correct calculations (partial marks are given for having a correct start). 1 point for indicating 15 apples are needed in total.

Part G *(4 points)* Given a graph of an indifference curve between ice cream (Product A) and sprinkles (Product B):



– (2 points) Write a possible equation for the consumer utility function in the format: $U(A, B) = A^x B^y$. Find one possible set of values for x and y. $U = A$ (or A^x where x is a positive constant). 2 points for any correct answers. Note: marks may be deducted for any extraneous or incorrect work.

(2 points) Explain, in words, under what circumstances indifference curves would be represented as horizontal lines. You may use the example from Part G (1) to help you explain. Justify your answer from the consumer's perspective.

1 point for indicating the indifference curve is horizontal when the item on the x-axis (or sprinkles in this case) does not affect consumer satisfaction. 1 point for indicating consumer satisfaction is only dependent on one item (ice cream in this case.) Note: marks may be deducted for any extraneous or incorrect work.

Problem 5: Committing to the Bit (20 Points)

This question will explore how the Federal Reserve uses monetary policy to attempt to control interest rates in the economy.

Consider the below Taylor Rule, that prescribes the federal funds rate the Fed should set given inflation and output:

$$i^{FF} = 2\% + \pi + 0.5(\textit{inflation gap}) + 0.5(\textit{output gap})$$

where:

$$\begin{gathered} i^{FF} = \textit{nominal} \text{ federal funds rate} \\ \pi = \text{actual inflation level} \\ \textit{inflation gap} = \textit{actual inflation - target inflation} \\ \textit{output gap} = \frac{\textit{actual output}}{\textit{target output}} - 1 \end{gathered}$$

Part A *(2 Points)* A typical inflation target for central banks to pursue is 2%. Suppose also that the current inflation is 1%, and the output gap is -4%. According to the rule above, what is the nominal federal funds rate the Fed should set?

$i^{FF} = 2\% + 1\% + 0.5(1\% - 2\%) + 0.5(-4\%) = 0.5\%$ *+2 for correct answer*

Part B *(2 Points)* Note that the output gap depends on the target output level, which is purely an estimate. Suppose the Federal Reserve estimated this level incorrectly and let $Y^{correct}$ indicate the *true/correct* target output. How would the economy respond to the interest rate set by the Fed if there is a positive inflation gap, actual output is greater than $Y^{correct}$ and the target output estimate is too high?

$i^{FF} = 2\% + \pi + 0.5(\textit{inflation gap}) + 0.5(\frac{\textit{actual output}}{\textit{target output}} - 1)$ Note that since actual output is greater than $Y^{correct}$, the true output gap is positive. If the estimated target output is too high, the federal funds rate set by the Fed will be too low. One possible result of this is continued inflationary pressures. *+1 for rate too low, +1 for correct explanation of effect*

Part C *(1 Point)* Suppose the Federal Reserve did indeed estimate the target output level incorrectly. The actual output gap is -7%. What is the actual interest rate the Fed will need to set?

$i^{FF} = 2\% + 1\% + 0.5(1\% - 2\%) + 0.5(-7\%) = -1\%$ *+1 for correct answer*

Part D *(2 Points)* You may have noticed that a problem has arisen–what economists call the *zero lower bound*. Why is this a problem? Think about how the economy would respond to the interest rate you found in Part C above.

Near the zero lower-bound, since interest rates are so low, the Fed will be unable to conduct successful monetary policy as interest rates may go negative (as above). Negative interest rates are damaging as they can lead to cash hoarding, reduce profits of banks, distort investment decisions, and lead to dangerous disinflationary spirals. *+2 for correct reasoning*

At the zero lower bound, the Federal Reserve may use a form of monetary policy called forward guidance, in which the Fed indicates the future direction of interest rates in an attempt to control the long term interest rate, which is what the economy actually responds to. Consider the model where the 10 year interest rate is a function of the average short term interest rate and a term premium:

$$i^{10yrs} = \textit{(average short term rate for years 1-10)} + \textit{term premium}$$

For the remainder of this problem, suppose the term premium is fixed at 1.8%.

Part E *(2 Points)* Suppose that the short term interest rate is expected to be 2% for the next 10 years. What will be the long term interest rate, i^{10yrs}?

$i^{10yrs} = 2\% + 1.8\% = 3.8\%$

+2 for correct anaswer

Part F *(2 Points)* The chair of the Federal Reserve is only willing to deviate from the standard 2% short term rate for at most 5 years. How low will the short term rate need to be kept so that the long term interest rate is 2.8%?

Part F Set-up: $2.8\% = \frac{2\%(5)+x(5)}{10} + 1.8\%$. Solving, we get that $x = 0\%$. *+2 for correct answer*

Set-up: $2.8\% = \frac{2\%(5)+x(5)}{10} + 1.8\%$. Solving, we get that $x = 0\%$. *+2 for correct answer*

Part G *(5 Points)* Suppose the Federal Reserve has committed to the policy above and five years have passed. However, an exogenous shock hits the economy that causes the long term rate to increase. To achieve the desired 2.8% long term rate, the Fed decides to discard their previous commitment and keep rates low for longer. What problems might arise from this decision?

Possible answer: The main problem here is one of commitment. Note that forward guidance depends critically on the assumptions on *future* interest rates (i.e. the average short term rate). Through forward guidance, the Fed attempts to alter people's beliefs on the future direction of interest rates but this relies on their credibility: if people don't believe in the Fed, forward guidance will not be as effective. The Fed making a new commitment in the middle of their previous one damages this credibility, and thus risks rendering their forward guidance policy ineffective. *Note:* Answers discussing how keeping interest rates low for longer may create problems regarding the zero-lower bound are technically correct, but do not address the core problem of recommitting. In fact, forward guidance is often employed as a *solution* to problems with the zero lower bound.*3 points for valid answer (correct economic reasoning, for example, problems with the zero lower bound), 5 points for answer containing references to the problem of commitment*

Part H *(4 Points)* Before the chair is able to implement the policy from Part F, some outside shock causes the desired long term interest rate to decrease to 2.5%. Assuming the Federal Reserve is still unwilling to deviate from the standard 2% short term rate for more than five years, what problem arises? Without altering the standard 2% interest rate, how could you change the situation above to address this problem?

Using the same framework as in Part F, we see that the Fed will need to set a negative interest rate under these conditions. One solution to this would be to deviate from the standard 2% rate for longer than five years, which would allow the long term rate to decrease more. *+1 point for identifying problem of negative interest rate, +2 points for identifying a solution that would solve the problem, +1 point if solution is feasible (e.g. does not attempt to affect exogenous factors) and explains how the solution can be achieved.*

Problem 6: Congestion Pricing for Dummies (20 points)

In this problem, we explore the economic rationale for congestion pricing on urban roadways.

Mayor X wants to tackle traffic in her city's booming downtown district. She considers funding infrastructure improvements, like street widening and bus rapid transit (BRT) expansion, to address the issue, but her plans are costly and lack support from the city council. Disheartened, Mayor X prepares to declare defeat in the war on traffic until one of her aides suggests congestion pricing.

When a road is empty, each additional driver has no practical impact on other vehicles; the total cost of that driver's trip is simply their own time and fuel expense. Once the road becomes sufficiently crowded, however, each additional car slows down its peers. In other words, the marginal driver imposes a congestion cost on other road users. Congestion pricing seeks to correct this negative externality.

Part A *(10 points total)* Suppose that the average cost per driver is:

$$AC = 3 + 0.3x^2$$

where x is the number of vehicles downtown in thousands. This is the cost that an individual driver faces to traverse the district. Also suppose that the marginal cost of each additional driver to society is:

$$MC = \begin{cases} 5 + 0.1x^2 & x < 3.16 \\ 3 + 0.3x^2 & x \geq 3.16 \end{cases}$$

(1) *(3 points)* City officials estimate the demand to drive downtown on Sunday evening as:

$$X_D = 6 - P_x + 0.5 * P_{BRT}$$

where P_{BRT}, the price of a downtown bus ticket, is set at 2. How many drivers will use the road? What is the optimal number of drivers on the road? Should a congestion toll be levied? For simplicity, round your answers (and all following answers for this question) to the nearest hundredth. The realized number of drivers on the road occurs where $P_X = AC$. The equation $7 - x = 3 + 0.3x^2$ finds $x = 2.35$ thousand drivers. The optimal traffic level occurs where $P_X = MC$. The equation $7 - x = 5 + 0.1x^2$ finds $x = 1.71$ thousand drivers to be the optimal level. A toll is needed since optimal and realized traffic levels differ. **1 point for realized, 1 point for optimal, 1 point for toll necessary**

(2) *(3 points)* The city anticipates demand the next Monday morning to be:

$$X_D = 12 - P_x + 0.5 * P_{BRT}$$

How many drivers will use the road? What is the optimal number of drivers on the road? Should a congestion toll be levied? The realized number of drivers on the road occurs where $P_X = AC$. The equation $13 - x = 3 + 0.3x^2$ finds $x = 4.35$ thousand drivers. The optimal traffic level occurs where $P_X = MC$. The equation $13 - x = 5 + 0.1x^2$ finds $x = 4.35$ thousand drivers to be the optimal level. No toll is needed in this scenario since realized and optimal traffic levels are equivalent. **1 point for realized, 1 point for optimal, 1 point for no toll**

(3) *(2 points)* For the case where a toll was useful, what amount should the city charge? [Hint: You can conceive of the toll as a tax that raises AC to the level of MC at the optimal traffic level.] Given the optimal traffic level (x^*), find MSC and AC @ x^*. Subtract MSC - AC for the optimal toll. $AC = 5 + 0.1(1.71)^2 = 5.29$. $MSC = 3 + 0.3(1.71)^2 = 3.88$. Optimal toll = 1.41. **2 points for correct toll and work**

(4) *(2 points)* Given the previous questions in this section, would it be economically optimal for the city to implement a static or dynamic congestion price? Identify a potential drawback to your chosen policy. A dynamic toll would be optimal to account for changing demand. Drawbacks of a dynamic toll might include information costs to customers, administrative costs, unintended behaviors resuting from a potential time cutoff, etc. **1 point for dynamic, 1 point for a reasonable drawback**

Part B *(5 points total)* The availability of other transport options, such as bus rapid transit, also influences drivers' road use.

Note that the test as released mistakenly referenced the demand equation from A.2, not A.1 (the correct part). Teams that solved B.1 using either equation were awarded points, so this error did not impact grading.

(1) *(3 points)* Mayor X wonders how expensive it would have been to use BRT subsidies alone to reduce downtown traffic. Using the cost equations and P_{BRT} from Part A, as well as the demand equation from A.1, calculate the BRT subsidy necessary to induce the optimal traffic quantity. [Hint: remember that the cost faced by individual drivers is equal to AC.] To find the subsidy, subtract an "s" term from P_{BRT} or use another equivalent method. E.g., $X_D = 12 - P_x + 0.5 * (P_{BRT} - s)$. To solve for the optimal subsidy, substitute $X_D = x^*$ and $P_x = AC$. In this case, $1.71 = 6 - AC + 0.5(2 - s) = 6 - (3 + 0.3(1.71)^2) + 0.5(2 - s)$, so $s = 2.85$. **1 point for substitution, 2 point for optimal s**

(2) *(2 points)* Perhaps Mayor X elects to take a hybrid approach to downtown traffic. Suppose she introduces a congestion price and a BRT subsidy as a linked, revenue-neutral program: all funding from the toll is used to sponsor transit. What is the smallest congestion charge the city can impose to reach the optimal traffic level? To set up the equation, substitute $P_x = (AC + s)$ and $Py = (Py_0 - s)$. In this case, $1.71 = 6 - (AC + s) + 0.5(2 - s) = 6 - ((3 + 0.3(1.71)^2) + s) + 0.5(2 - s)$, so $s = 0.94$. **1 point for setup, 2 point for optimal s**

Part C *(5 points total)* Anticipating a tight re-election campaign, another of Mayor X's staffers advises her to avoid potential political blowback from congestion pricing and utilize other programs to tame traffic.

(1) *(3 points)* Rather than tolling drivers entering the crowded downtown, the staffer proposes, Mayor X should simply set a limit on the number of vehicles in the district at any given time. All drivers above the cap would be redirected to less busy external routes. Aside from administrative burden, why might such a quota system be economically inefficient? The cap allows entry with respect to an arbitrary characteristic, time of arrival. Congestion pricing, on the other hand, automatically sorts drivers by willingness to pay, restricting downtown access to the consumers who benefit most. The cap could decrease overall welfare relative to the congestion pricing scenario if low-WTP drivers entered downtown first, while high-WTP drivers were excluded. **3 points for explanation**

(2) *(2 points)* The aide then suggests raising the city's existing fuel tax to a level sufficient to achieve the optimal level of downtown traffic. The fuel tax would be implemented at all gas stations within municipal boundaries. Does this solution present a feasible alternative to congestion pricing? If not, why? The fuel tax could achieve the optimal downtown traffic level, but not without negative consequences elsewhere—the increased price would discourage driving outside of downtown, where traffic is presumably less of a problem. This would reduce the number of useful (socially desirable) car trips taken. There might also be a fairness issue: it could be seen as unfair for non-downtown drivers to pay the price for fixing downtown traffic. **2 points for explanation**