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Please write all answers in legible handwriting in the space provided. **3.5** points will be added to your score for signing your name, though those points will be deducted if the grader cannot read what you wrote on your pdf scan. For math questions, show all relevant work. **For questions with numeric answers, clearly circle or box your final answer.**

**Total points possible: 37.5**

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For the first 5 questions, circle **one** option from the multiple choice. The multiple choice are all based on *ToTC*.

1. (.5 points) Which of these is discussed on the last page of the introduction of Triumph of the City as a reason why urban development matters for the environment?
  - (A) Whether or not China or India choose to plan car-based cities (as seen in the U.S., especially) as their wealth grows will hugely impact energy demand and global emissions of carbon dioxide.
  - (B) An increase in the number and size of cities will make countries more productive and wealthy, allowing them to spend the necessary money to solve whatever environmental problems that might exist.
  - (C) The location and growth of cities in places like Brazil or Indonesia threaten rainforests and biodiversity.
  - (D) Cities are engines of creativity and knowledge; solutions to environmental problems will be developed in the colleges, universities, and research labs of cities.
2. (.5 points) One theme repeated by Edward Glaeser in these first couple dozen pages of Triumph of the City is that a city is fundamentally made up of...
  - (A) its people.
  - (B) its buildings.
  - (C) its location.
  - (D) its infrastructure.
  - (E) its firms.
3. (.5 points) What technology does chapter 2 cite as a "knowledge-destroying-idea"?
  - (A) Henry Ford's assembly line
  - (B) inland waterways, such as the Erie Canal
  - (C) Thomas Edison's light bulb
  - (D) Gustavus Swift's refrigerated railcar

4. (.5 points) As seen in the example of Detroit, what is one of the potential pitfalls of a local income tax (i.e., one imposed at the level of a politically separate municipality—not an entire metropolitan area)?
- (A) Income taxes are more regressive than sales taxes (i.e., they disproportionately burden lower-income households more).
  - (B) Higher-income households may simply move to neighboring municipalities with no lower local income taxes or no local income tax.
  - (C) Local income taxes discourage innovation.
  - (D) There is less democratic control over how the revenues of local income taxes might be spent
5. (.5 points) Why was it especially common for farmers to take their grains (like corn) and distill it into alcohol or feed it to livestock (such as pigs) in the early nineteenth century and before?
- (A) Before the advent of railroads and automobiles it was prohibitively expensive to transport bulky, low-value grains over large distances by land.
  - (B) Alcohol and preserved meat (such as ham) have last longer before spoiling than grain, so they can be stored for longer periods or transported slowly.
  - (C) Alcohol and meat both have more calories per unit of weight than grain, so transportation costs per calorie were lower for alcohol and meat.
  - (D) All of the other answers are correct.
6. (.5 points) By Edward Glaeser's reckoning (as expressed in chapter 3 of *Triumph of the City*) to whom should we compare the urban poor living in the favelas of Rio de Janeiro?
- (A) to the urban poor of Lisbon, capital of Portugal, Brazil's former colonial ruler
  - (B) to the rural poor living in northeastern Brazil
  - (C) to the urban poor in other South American metropolises, such as Buenos Aires, Santiago, or Lima
  - (D) to the poor in the ghettos of U.S. cities (such as Los Angeles)
7. (.5 points) Which of these ideas does Glaeser recommend to alleviate urban poverty?
- (A) invest in agricultural improvements so that agricultural workers will be more productive and less inclined to move to cities
  - (B) pay rural residents to continue living in rural areas, and allow them to spend the extra money however they wish
  - (C) improve rural infrastructure (transport, communications, and utilities) so that many of the urban poor will return to rural areas and not further stress the already strained urban infrastructure
  - (D) improve urban infrastructure (roads, transport, and utilities) so that more people can benefit from the advantages of living in a city

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8. (.5 points) What is the precise meaning of the term “self-protecting urban innovation”?
- (A) A cities ability to protect itself from disease
  - (B) A cities ability to generate the information needed to solve their own problems
  - (C) A description of the scale and scope of the ideas generated by cities
  - (D) None of the above
9. (.5 points) What is the main implication from the *fundamental law of road congestion*, as described in chapter 4?
- (A) When roads are public, no policy can improve congestion
  - (B) Building new lanes on a road always decreases congestion, but not by very much
  - (C) Adding lanes to roads will not necessarily reduce congestion
  - (D) None of the above
10. (.5 points) As described in Chapter 5, why are people willing to accept lower real wages in certain cities? For example, why doesn't everyone from Honolulu move to Dallas?
- (A) People usually live where they are born and do not care much about their wage
  - (B) Lower real wages are usually made up for with nicer weather
  - (C) Lower real wage cities generally have higher overall amenity values; parks, schools, weather, etc all might be better
  - (D) None of the above
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**Short Answer**

11. (3 points) Consider the following equations describing two counties  $A$  and  $B$ 's possible combinations of bread ( $Q_b$ ) and wine ( $Q_w$ ) Production:

$$\text{County A : } Q_b = 20 - 4Q_w$$

$$\text{County B : } Q_b = 14 - 2Q_w$$

- A)** Graph each counties Production Possibilities Frontier for bread and wine (on the same graph). Draw wine on the x-axis and bread on the y-axis. Carefully label each component. (1 points)

- B)** Which county has the absolute advantage in wine? Which county has the absolute advantage in bread? Explain (briefly) how you know. (1 points)

- C)** Who has the comparative advantage in wine? Who has the comparative advantage in bread? (1 points)

12. (6 points) The city of Springfield lies at the west end of a railroad. To the east, there are one hundred miles of plains along which there are several towns—all connected to by rail. To the east of Springfield are fifty miles of mountains, whose small villages are connected by a few winding dirt roads. The only factory in the region is in Springfield. It produces widgets at a cost of \$20 per unit at the factory door. Thanks to the rail line, the transport cost to anywhere west of Springfield is \$0.4 per mile. Given the poor state of the roads through the mountains, the transport costs to anywhere east of Springfield is \$0.8 per mile.

**A)** Graph the costs of widgets produced throughout the entire 150-mile region. Carefully label the costs at the factory, at the far western end of the region, and at the far eastern end of the region (1 point)

**B)** Assume that the cost of making a widget at home is \$44. What is the market area for the factory? (That is, how many miles west of Springfield will it stretch, and how many miles east of Springfield will it stretch?) (1 point)

In reality, one of the key inputs for widgets is easier for the residents of the western plains to acquire. For all remaining parts of the problem, assume that the cost of making widgets at home anywhere west of Springfield is actually \$32, and the cost of making widgets at home is \$44 anywhere east of Springfield.

- C) Now what is the market area for the factory? (That is, how many miles west of Springfield will it stretch, and how many miles east of Springfield will it stretch?) Show your work. (1 point)

The owners of the factory would like its market area to extend more broadly, and they are considering two investment options:

- First, they could help the government of the region finance the upgrading and paving of the mountain roads, which would reduce the transport costs east of Springfield to only \$0.6 per mile. (The transportation costs west of Springfield would stay at \$0.4 per mile.)
- Second, they could purchase and install expensive new equipment in the factory that would reduce the cost of a widget at the factory door to only \$14 per unit. Each of these options would cost exactly the same, and the owners of the factory can choose only one of these options. Assume that potential customers for widgets are distributed evenly across the entire 150-mile region.

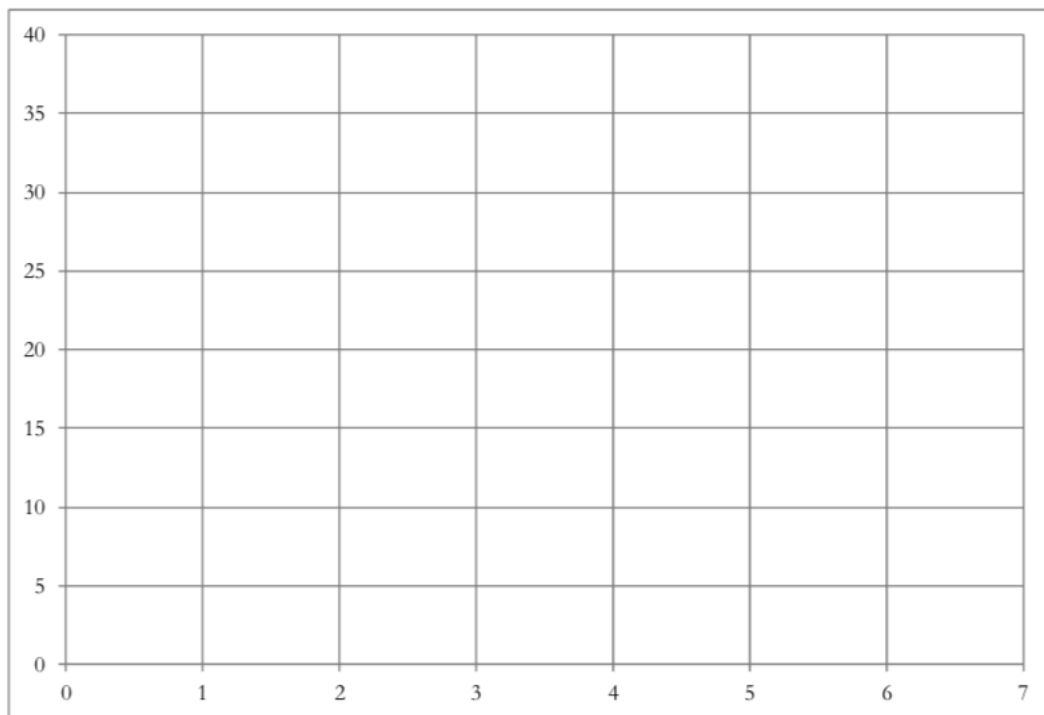
- D)** How many additional miles (on either side of Springfield) would be added to the factory's market area under the first investment option of upgrading and paving the mountain roads? Show your work. (1 point)
- E)** How many additional miles (on either side of Springfield) would be added to the factory's market area under the second investment option of installing new equipment in the factory? Show your work. (1 point)
- F)** Given the answers to parts d) and e) above, which investment option will the factory owners choose? Briefly explain why they will go with that option. (1 point)

13. (5 points) Consider an entrepreneur who sells jewelry for \$50 per piece. Clustering with similar entrepreneurs would increase labor costs, but it would allow some of the intermediate materials to be made at larger scales, thus reducing per-unit costs.

A) Fill out the rest of the table below, finding the total cost per piece as well as the profit per piece for an entrepreneur depending on how many other entrepreneurs there are in a cluster. (1 point)

Number of entrepreneurs	1	2	3	4	5	6	7
Labor cost per piece	5	6	8	11	15	19	27
Cost of materials per piece	25	20	16	14	12	10	9
Total cost per piece							
Profit per piece							

B) Using the data in the table above graph the labor costs per piece, the costs of materials per piece, and the total costs per piece as functions of the number of entrepreneurs in a cluster. (1 point)

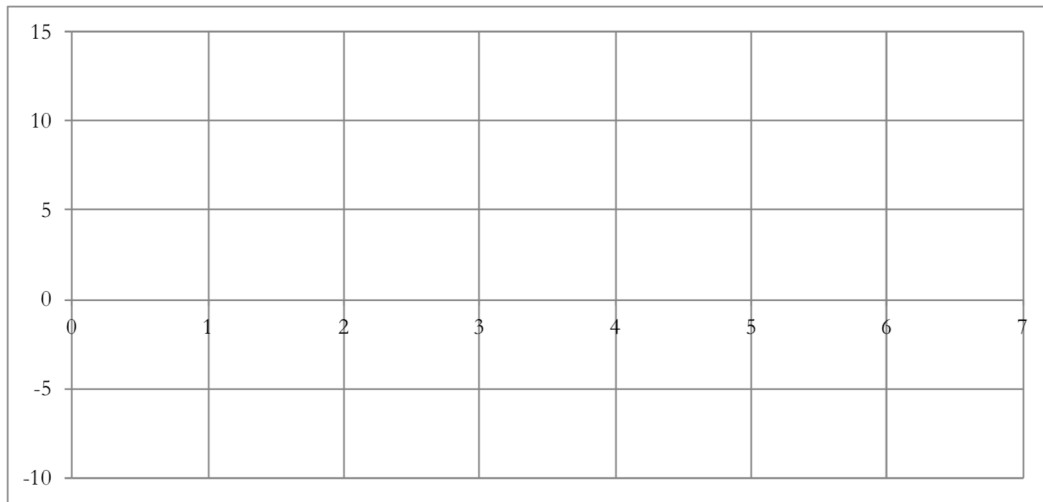


C) Fill out the following table and graph, finding the profit gap between locating in clusters of more than one entrepreneur compared to locating to an isolated site (i.e., a cluster of size 1). That is, how much more profit will the firm earn in a cluster of multiple entrepreneurs compared to working in an isolated site (i.e., a cluster of size 1)? For the graph, the x



axis should be number of entrepreneurs in the cluster and the y axis should be the profit gap. (1 point)

Number of entrepreneurs	1	2	3	4	5	6	7
Profit gap	(0)						



**D)** What would we expect the equilibrium cluster size to be? No explanation needed (yet). (1 point)

**e)** Briefly explain why the equilibrium cluster size wouldn't be smaller than your answer in part (d). (1 point)

14. (2 points) Assume that the rank-size rule (Zipf's law) for cities is exactly true and that the third-largest city in a region has 3 million people.

**A)** How many people live in the region's largest city? Show your work. (1 point)

**B)** How many people live in the region's fourth-largest city? Show your work. (0.5 points)

**C)** How many people live in the region's tenth-largest city? Show your work. (0.5 point)

15. (5 points) Recall the locational indifference condition in the model of housing prices with commuting costs:

$$\Delta P \cdot h(x) + \Delta x \cdot t = 0$$

- A)** If  $h(x) = 750$ , have we modeled consumers as being able to substitute? How do you know? (1 point)

- B)** Derive the slope of the bid-rent curve when  $h(x) = 750$  (1 point)

- C)** Now suppose  $h(x) = 650 + x^2$  for  $x \geq 0$ . Graph this equation and provide an interpretation for  $h(0) = 650$  (hint: think about what  $x$  represents). (1 point)

- D)** Rederive the slope of the bid-rent curve using  $h(x) = 650 + x^2$  (1 point)
- E)** Find the distance  $x$  at which the two bid rent curves from part B and D have equal slope.  
(hint: set  $h(\cdot)$  from part B equal to part D and solve). (1 point)

16. (7 points) **A multi-sector model** Consider a version of the manufacturing bid-rent curve, but with two sectors. Let  $x_1$  and  $x_2$  be the distance that firms in sector 1 and sector 2 locate away from the city center. Firms face freight, labor, and land costs — but **no intermediate goods** cost. To simplify the algebra, let's also assume that firms in each sector use only one unit of land (and thus the land cost,  $LC(x_i) = P(x_i)$  for  $i = 1, 2$ ). The labor costs for each firm (as a function of distance to center) is given by:

$$L(x_1) = 20 - A_1 * x_1$$

$$L(x_2) = 30 - A_2 * x_2$$

The freight costs for each firm as a function of distance is given by

$$F(x_1) = (B_1 + 3) * x_1$$

$$F(x_2) = (B_2 + 3) * x_2$$

- A)** Write out the profit function for a firm in each sector. You should provide two equations. Do not assume that revenue is equal in each sector. (1 points)

- B)** Use your answer from part A to derive the bid-rent curves for manufacturing firms in each sector. (1 points)

- C)** For each sector, find the point at which the WTP for land is zero (this won't be a number, but a function of the model's parameters). (2 points)
- D)** Interpret your answer from part C. How does the distance you calculated for sector one change with  $A_1$ ? Provide economic intuition for your answers. (1 point)

- E)** Now assume that  $A_1 = 5$ ,  $A_2 = 6$ ,  $B_1 = 7$  and  $B_2 = 4$ . Furthermore, you may now assume that  $TR_1 = TR_2 = 40$ . Find the range of distances from the center each sector will be located. Hint: draw a graph of these lines. Remember: land is always allocated to the highest bidder. Don't worry about units and note that your answer may include fractions. (2 points)