Name: _____**KEY**_____

100 points total. Point values for each question are as indicated. Answer each question in the space provided. General advice: show your work, including any formulas or diagrams that you use in reasoning through your answers.

1. (15 pts.) Walmart notices that when it reduces the price of its Schick 4-pack Xtreme3 men's disposable razors from $7.12 to $5.97, weekly sales at a typical Walmart SuperCenter increase by 25%.

    (a) Calculate own-price elasticity of demand for Schick Xtreme3 men's disposable razors. Show your work.

    (b) Thinking about economic factors affecting whether consumers are likely to be sensitive or insensitive to a price change, what do you think explains the number you calculated in (a)?

    (c) Walmart keeps the price of its Schick 4-packs of women's disposable Xtreme3 razors constant at $7.12. Weekly sales at a typical SuperCenter fall from 105 to 95. Calculate the cross-price elasticity of demand between men's and women's Schick Xtreme3 razors, showing your work. Briefly interpret your answer.

(a) E_D = *[% change in Q_D (X)] / [% change in P_x]* = - *[(Q_1-Q_0) / ½ (Q_1+Q_0)] / [(P_1-P_0) / ½ (P_1+P_0)]*
    E_D = *[0.25] / [(5.97 – 7.12) / ½ (5.97 + 7.12)]* = *[0.25] / [0.1757]* = *1.423*

(b) Since E_D > 1, demand is elastic, i.e. consumers are relatively responsive to a change in the price of Schick 4-pack Xtreme3 men's disposable razors. That is probably because there are so **many good, close substitutes** for that specific (narrowly defined) product.

(c) $E_{X,Y}$ = *[% change in Q_D (X)] / [% change in P_Y], where X=women's razors and Y=men's razors. In other words, do some women decide to buy men's razors with blue or green plastic handles instead of women's razors with pink plastic handles when the price of identical men's razors falls by over 17% while the price of women's razors stays the same?*

$E_{X,Y}$ = *[95 – 105) / ½ (95 + 105] / [(5.97 – 7.12) / ½ (5.97 + 7.12)]* = *[0.10] / [0.1757]* = *0.569*

Since cross-price elasticity is positive, we infer that men's and women's Schick 4-pack Xtreme3 disposable razors are (weak) substitutes.

2. (15 pts.) This question is based on a research paper entitled "The co-movements of cotton, polyester, and crude oil prices." Basic facts are that cotton and polyester are the two most popular fibers used in textile fabrics for clothing. Cotton is a natural fiber while polyester is a chemical fiber made from petroleum. Now for your analysis. Suppose the fracking revolution in the technology of oil and gas production spreads to other parts of the world. (a) Illustrate and explain what will happen in the world market for crude oil, using supply and demand analysis. (b) Given your answer to (a), use supply and demand analysis to explain how the market for polyester fiber will be affected. (c) Given your answer to (b), use supply and demand analysis to explain how the market for cotton fiber will be affected.

Crude oil market
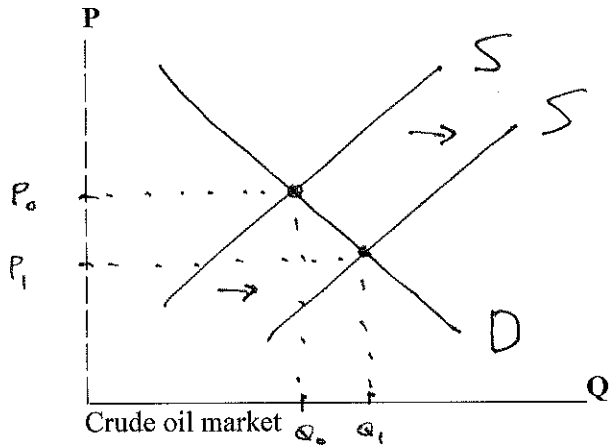
Fracking changes the technology of producing oil and natural gas. As other parts of the world adopt fracking technology, the supply curve for crude oil will shift to the right, leading to lower petroleum prices.

Polyester fiber market
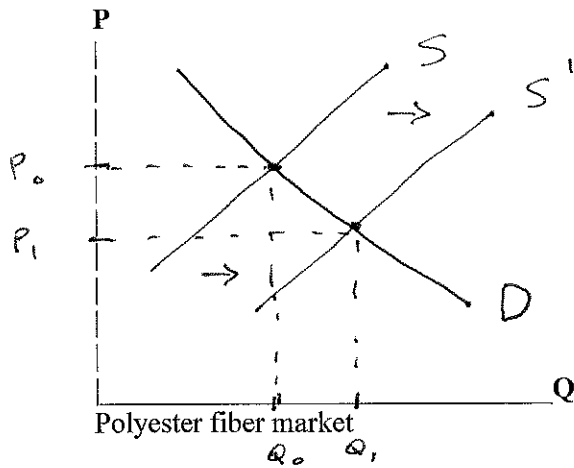
Petroleum is a key input in producing polyester fiber. A fall in the price of an input shifts the supply curve to the right, leading to lower prices for polyester fiber.

Cotton fiber market
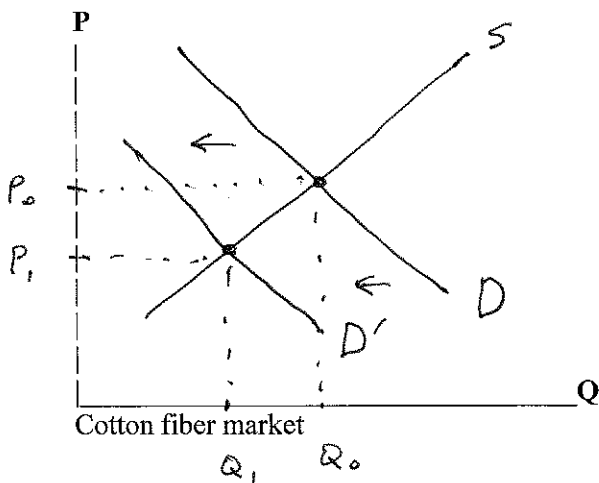
Clothing manufacturers can use either polyester or cotton to make clothes. When the price of polyester fiber falls, the demand for a substitute fiber (cotton) will decline or shift to the left. Cotton prices are expected to fall.

3. (15 pts.) Your professor's younger sister owns and operates a sandwich shop in Fort Walton Beach, FL. The income statement for her business shows annual revenues of $300,000. Costs include wages for hourly employees ($70,000), utilities ($30,000), wholesale cost of food and other supplies ($80,000), taxes ($10,000), advertising ($10,000), and insurance ($10,000). She quit her job managing an Arby's where she earned $50,000 per year, but she pays herself no salary in this business. She and her husband own the strip mall where her sandwich shop is located, and the space occupied by her shop previously rented for $24,000 per year. They have $80,000 invested in the business, which they could recover if they liquidated. They ask you to help them figure out the "rate of return" they are earning on their $80,000 that they have invested in the sandwich shop. Evaluate the economic profitability of their business.

Financial accounting profits = Total Revenue – Total Explicit Costs
Total Explicit Costs = $70,000 + $30,000 + $80,000 + $10,000 + $10,000 + $10,000 = $210,000
Accounting profits = $90,000

Economic profits = Total Revenue – Total Explicit Costs – Total Implicit Costs
Implicit Costs: Opportunity cost of her time = $50k in foregone salary
Opportunity cost of foregone rent = $24 k
Opportunity cost of interest earnings foregone on $80k invested in the business

Not factoring in foregone interest earnings on her $80k investment, she is earning $90k - $74k = $16k in economic profit. $16k / $80k = **20% rate of return,** *which is well above an expected long-run market return on equities of 5-7%. Pretty good business opportunity!*

4. (20 pts.) As director of operations for Amazon's U.S. fulfillment centers, you oversee a production process that has three primary factors of production: (1) warehouses of given size and configuration, which we will take as fixed over the time period under consideration; (2) humans, who stand at work stations where they pack boxes with items that robots bring to them; and (3) robots, who travel around the warehouse picking out shelves containing items that people like me have ordered online. You have optimized the mix of humans (L) and robots (K) at all of your warehouses based on paying humans $10 per hour and robots $5 per hour. In a typical warehouse there are twenty work stations with one human at each one and one hundred little orange robots motoring around the warehouse bringing things to the humans. With this mix you are able to process 500 orders (Q) per hour on average. Having observed productivity when the number of humans is increased or decreased by one and when the number of robots is increased or decreased by one, you have put together the following productivity matrix:

		Robots (K)		
		K = 99	K = 100	K = 101
Humans (L)	L = 19	Q = 470	Q = 480	Q = 489
	L = 20	Q = 490	Q = 500	Q = 509
	L = 21	Q = 508	Q = 518	Q = 527

Now for the questions:
(a) Does this production process exhibit diminishing marginal returns in the short run? Since the obvious answer is yes, select some data points from the above table and use the concept of marginal product to explain how you see diminishing returns in your production process.
(b) Confirm that at the current prices for L and K, your mix of inputs (L=20 and K=100) roughly minimizes the cost of processing 500 orders per hour. Show the formula you use in arriving at this answer, and explain what it means.
(c) Amazon announces that it is raising the starting wage for all employees to $15 per hour. Using words and the formula from (b), explain how you as director of operations will respond over time in the configuration of humans and robots you employ in your warehouses.

(a) *Keeping L constant at L=19, increasing K from 99 to 100 causes Q to increase by 10, from 470 to 480, i.e. $MP_K = 10$. Increasing K from 100 to 101 causes Q to increase by 9, from 480 to 489, i.e. $MP_K = 9$. Diminishing marginal returns. Alternatively, keeping K constant at K=99, increasing L from 19 to 20 causes Q to increase by 20, from 470 to 490, i.e. $MP_L = 20$. Increasing L from 20 to 21 causes Q to increase by 18, from 490 to 508, i.e. $MP_L = 18$. Diminishing marginal returns.*

(b) *Cost minimization requires that spending one dollar more or less on labor would yield the same change in output as spending one dollar more or less on capital; i.e. $MP_L/w = MP_K/v$, where w=wage rate and v=rental rate on robots.*
At L=20 and K=100 $MP_L = 18$ and $MP_K = 9$. Thus $18/10 = 9/5$ and costs are minimized with this combination of L and K.

(c) *If the wage rate increases from $10/hr to $15/hr while the rental rate for robots stays the same, the necessary condition for cost minimization no longer holds: $18/15 < 10/5$. So to minimize the cost of the chosen rate of output (Q=500), you would need to employ fewer humans and more robots.*

5. (5 pts.) Why might ABInbev, makers of Budweiser, have lower per unit costs than craft brewers like West 6th or Country Boy?

*With some production processes, like brewing beer, there are **engineering relationships** between the cost of constructing the container vessel itself and the volume of product that can be processed in each batch, known as the "rule of two-thirds". ABInbev uses much larger brewing vats than the typical craft brewer (see the pictures in the lecture 4 ppt. slides). As a result, the cost of brewing a 12 oz. can of beer declines with the scale of the brewing operation.*

6. (5 pts.) Boeing's 787 Dreamliner has been a very successful plane for the company, with hundreds having been produced and sold. Boeing had considerable trouble, however, selling a dozen or so 787's known as the terrible teens. Briefly explain why, using concepts we have discussed in this course.

*With many complicated production process, workers "learn by doing" as they produce successive units of the good. As a result, as the cumulative output of the product increases, per unit production costs fall. This is known as the **learning curve**. Boeing and its workers went through some serious learning curve effects as they produced the early 787 airplanes. The market recognized this, so buyers were reluctant to take delivery of the terrible teens, worried that the 13th 787 to roll off the line might have hidden defects that would get worked out in later iterations of the plane.*

7. (5 pts.) Briefly sketch the LRAC curve for a typical fast-food restaurant, and use it to illustrate and explain why there are only a handful of fast-food restaurants in Lawrenceburg, KY.
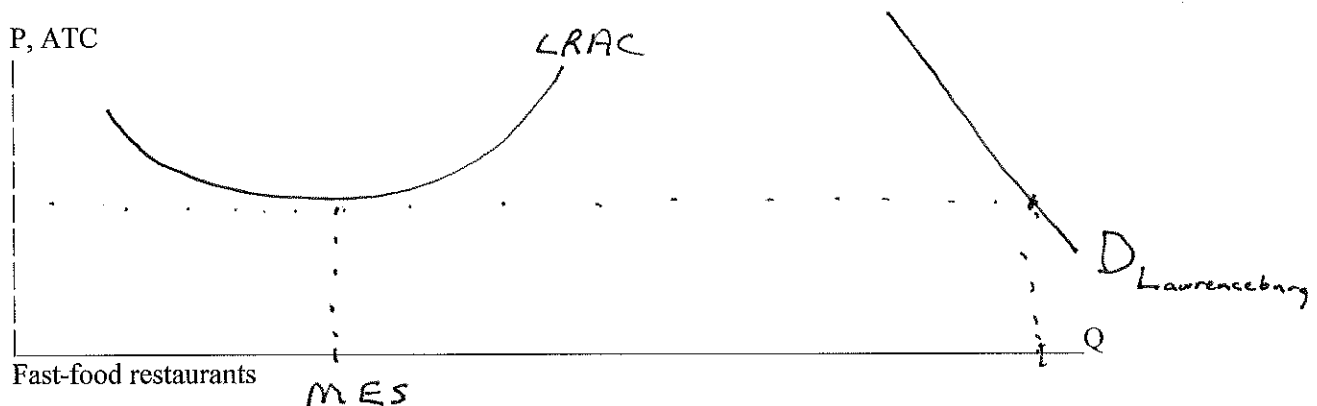
Minimum efficient scale for a typical fast-food restaurant is illustrated above. Lawrenceburg is a small-enough town, as illustrated by the market demand for fast-food meals in L-burg above, such that it can only support a handful of efficient-sized restaurants.

8. (5 pts.) Thinking about firms' make or buy decisions and reasons for using the market vs. reasons for vertical integration, explain Barnhart Crane Company's business model.

*Construction companies typically only need crane services at specific stages and for limited durations during a typical construction project. So if they owned their own crane, it and its operator would be idle quite regularly. Barnhart Crane's business model is predicated upon **aggregating uncorrelated demands**. It keeps its cranes and specialized operators fully employed by moving them from one job site to another, as needed by its many different construction company customers.*

9. (5 pts.) Why might large chicken processing companies like Tyson and Cargill enter into long-term contractual relationships with poultry farmers instead of relying on arm's length spot market acquisition like beef processing companies tend to do?

*Chicken farming has significant economies of scale in production, such that efficient chicken farms produce hundreds of thousands of chickens. As a result, it only takes a handful of MES chicken farms to keep an efficient-sized chicken processing plant fully supplied. Because of the **extensive coordination** that is necessary between farmers and processors, chicken processors typically establish long-term contractual relationships with farmers to make sure their plants have sufficient supply.*

East of the Mississippi River, cattle farming does not exhibit significant economies of scale in production. Cattle farmers with fewer than 100 cows are cost-competitive with larger operations. Beef processing plants can rely on the random production decisions of hundreds and hundreds of small cattle farmers who show up to sell their animals at cattle auction houses. As a result, they can "buy" rather than "make".

10. (10 pts.) Why are firms' short-run average total cost curves always U-shaped? First give an algebraic/graphical answer. Second, explain the economic logic behind the declining, bottom/flat, and increasing portions of the SRATC curve.

In the short run some inputs are fixed while other inputs can be varied. As a result, SRTFC is constant with output, while SRTVC is increasing with output. AFC (= TFC/Q) thus is declining in shape. Because of the law of eventually diminishing marginal returns, AVC (=TVC/Q) eventually slopes upward, and sharply upward when diminishing returns bite hard. The short-run average total cost curve is the sum of AFC and AVC. The dominant effect on its shape initially is the decline in AFC, as overhead expenses are spread over more and more output. Eventually, the effect of diminishing returns takes over, and the upward-sloping portion of the AVC curve dominates. So the SRATC curve at first declines, bottoms out, and then slopes upward. The bottom of the U can be interpreted as the designed operating capacity of the particular plant (fixed amount of capital) in question.