Supplemental Study Questions for the Midterm Exam  
(to be combined with study questions for Quizzes 1 and 2)

2*.1. Give short, concise definitions of the following:
   a. isoquant
   b. total product function
   c. average product function
   d. marginal product function
   e. marginal rate of technical substitution
   f. lower ridge line
   g. upper ridge line
   h. decreasing returns to a fixed factor
   i. increasing returns to a fixed factor
   j. constant returns to a fixed factor
   k. law of diminishing returns factor
   l. decreasing returns to scale
   m. increasing returns to scale
   n. constant returns to scale
   o. long-run expansion path
   p. short-run expansion path
   q. long run total cost function
   r. long run average cost function
   s. long run marginal cost function
   t. economies of scale
   u. diseconomies of scale
   v. constant economies of scale
   w. total fixed cost function
   x. total variable cost function
   y. average fixed cost function
   z. average variable cost function
   za. short run total cost function
   zb. short run average cost function
   zc. short run marginal cost function

2*.2a. Does the total-product-of-labor function \( TP(\ell) = 3\ell^2 \) exhibit decreasing (marginal) returns to the fixed factor \( k \)? Why or why not?
   b. Does the production function \( f(\ell, k) = 5\ell k \) exhibit increasing returns to scale? Why or why not?

2*.3. What are the relationships among marginal products, the marginal rate of technical substitution, and the slopes of isoquants?

2*.4. Without referring to costs or the expansion path, explain why a profit-maximizing firm will always produce its output with a basket of inputs that lies between the ridge lines (assuming they are present) up to the point of intersection, if there is one.

2*.5. Why does the assumption of profit maximization imply that the firm will produce each output with a basket of inputs that minimizes cost?

2*.6. Explain why cost minimization for each level of output implies that the firm hires that basket of inputs for which
   a. the marginal rate of technical substitution equals the input price ratio.
   b. the marginal products per dollar of the two inputs are equal.
If you use a diagram in your answer, make the diagram large and label all curves, axes, and points.
2*.7a. Explain how, in a two-input world, the long-run total cost function is derived from the firm's production function or isoquant map.
   b. Explain how, in a two-input world, the short-run total cost function is derived from the firm's production function or isoquant map.
   c. Describe the relationship between the firm's long-run and short-run total cost curves and explain how the short-run curve can be tangent to the long-run curve.
   d. Describe the relationship between the firm's long-run and short-run average cost curves and between the firm's long-run and short-run marginal cost curves, and explain why that relationship occurs.

2*.8. Describe the relationship between the different kinds of returns to scale and the different kinds of economies of scale.

2*.9. Draw a diagram with cost curves illustrating the relationship between long-run and short-run total cost curves. Explain the tangencies between the long-run and short-run total cost curves in this diagram using another diagram containing isoquants and the expansion path. Make your diagrams large and label all curves, axes, and points.