Consider the following product and cost schedule for a representative firm.

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<th>Output</th>
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<th>AP_L</th>
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<th>TC</th>
<th>MC</th>
<th>AVC</th>
<th>ATC</th>
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Use a spreadsheet program for the graphs in questions 1-9.

**Product Curves**

(1) Graph total product. Indicate the range over which increasing, decreasing and negative returns to labor occur.
(2) Calculate the marginal product of labor (MP_L).
(3) Indicate the range over which increasing, decreasing and negative returns to labor occur.
(4) Calculate the average product of labor (AP_L).
(5) Graph the marginal and average products of labor together on the same graph.

**Cost Curves**

(6) Calculate total cost (TC).
(7) Graph the total cost curve. Indicate the range over which increasing and decreasing returns to labor occur.
(8) Calculate marginal cost (MC), average variable cost (AVC) and average total cost (ATC).
(9) Graph marginal, average variable and average total cost functions on the same graph. Note: Graph only the non-negative values.
(10) At what output is the average product of labor (AP_L) equal to the marginal product of labor (MP_L)?
(11) What are the implications for the average product of labor when AP_L = MP_L?
(12) What is total product when the MP_L is maximized?
(13) What is total product when the MP_L is zero?
(14) Assuming a constant price, how many workers should be hired if the firm wants to maximize total revenue?
(15) At the output at which the marginal product of labor is maximized, what is happening to marginal cost?
(16) At what output is marginal cost equal to average total cost? What are the implications for average total cost of the previous question?
(17) At what output is marginal cost equal to average variable cost? What are the implications for average variable cost of the previous question?
(18) What is the per unit cost of producing 60 units of output?
(19) What is the per unit labor cost of producing 60 units of output?
(20) What is the per unit fixed cost of producing 60 units of output?
Suppose that a firm has four possible scales of production. Figure One shows the four short run average total cost curves for the respective firm sizes represented by ATC₁ through ATC₄.

(21) Which scale of production is best when output, Q = 25? Based on your previous answer, what is the per unit cost of producing 25 units?

(22) Which scale of production is best when output, Q = 30? Based on your previous answer, what is the per unit cost of producing 30 units?

(23) Which scale of production is best when output, Q = 40? Based on your previous answer, what is the per unit cost of producing 40 units?

(24) Which scale of production is best when output, Q = 45? Based on your previous answer, what is the per unit cost of producing 45 units?

(25) Identify the long run average cost curve from Figure One.

(26) Over what output range (approximately) on the long run average cost curve are increasing returns to scale illustrated?

(27) Over what output range (approximately) on the long run average cost curve are decreasing returns to scale illustrated?

(28) Over what output range (approximately) on the long run average cost curve are constant returns to scale illustrated?