

AP MICROECONOMICS

Unit 3: Production, Cost, and the Perfect Competition Model

Topics 3.1 – 3.7 | Lesson Reference Guide

AP Exam Weight: 22-25% | ~14-16 Class Periods

What This Section Is About

Unit 3 moves behind the demand curve to examine how firms decide what to produce and at what cost. You will analyse how output changes with variable inputs, distinguish short-run from long-run cost behaviour, and master the $MR = MC$ profit-maximisation rule. The unit culminates in the perfectly competitive market model — the benchmark against which all other market structures are judged. These topics are tested heavily in both the multiple-choice section and FRQs every exam year.

Topics covered:

- 3.1 The Production Function - how labour and capital combine to generate output
- 3.2 Short-Run Production Costs - total, marginal, and per-unit cost curves
- 3.3 Long-Run Production Costs - economies and diseconomies of scale; LRATC
- 3.4 Types of Profit - accounting vs. economic profit; normal profit
- 3.5 Profit Maximisation - the $MR = MC$ rule in theory and practice
- 3.6 Firms' Short-Run Decisions - shutdown price vs. break-even price
- 3.7 Perfect Competition - market structure, firm behaviour, and long-run equilibrium

◆ One Firm, One Set of Cost Curves

Topics 3.2, 3.5, 3.6 and 3.7 all use the same firm so the numbers connect from graph to graph: $FC = \$8$ and $VC = 0.25Q^3 - 1.5Q^2 + 8.25Q$.

Key values: MC is lowest at $\$5.25$ ($Q = 2$) · $\min AVC = \$6$ at $Q = 3$ (shutdown price) · $\min ATC = \$8.25$ at $Q = 4$ (break-even price) · at $P = \$12$ the firm produces $Q^* = 5$ and earns $\$17$ profit.

TOPIC 3.1 — THE PRODUCTION FUNCTION

COLLEGE BOARD CED · ENDURING UNDERSTANDING PRD-1

Firms' production and cost constraints over different input and output levels shape optimal decisions in the short run and long run.

Learning Objective PRD-1.A

- Define (using graphs where appropriate) key terms and concepts relating to production and cost.
- Explain (using graphs where appropriate) how production and cost are related in the short run and long run.
- Calculate (using data from a graph or table as appropriate) the various measures of productivity and short-run and long-run costs.

Essential Knowledge

PRD-1.A.1 The production function explains the relationship between inputs and outputs both in the short run and the long run.

PRD-1.A.2 Marginal product and average product change as input usage changes, and hence, total product changes.

PRD-1.A.3 Diminishing marginal returns occur as the firm employs more of one input, holding other inputs constant, to produce a product (output) in the short run.

Inputs, Output, and the Production Function

A production function describes the maximum output (total product, TP) a firm can obtain from a given combination of inputs. In the short run, at least one input is fixed — typically capital while labour (L) varies. As more workers are added to fixed capital, output first rises rapidly, then more slowly, and eventually falls.

Marginal Product and Average Product

Marginal product (MP) is the additional output from one more unit of labour: $MP = \Delta TP / \Delta L$.

Average product (AP) is output per worker: $AP = TP / L$. MP rises when workers specialise (increasing marginal returns), peaks at the inflection point of the TP curve, then declines as the fixed factor becomes congested. Crucially, MP intersects AP at AP's maximum — a purely mathematical relationship: when $MP > AP$, AP rises; when $MP < AP$, AP falls.

$$MP = \Delta TP \div \Delta L \quad | \quad AP = TP \div L$$

The Law of Diminishing Marginal Returns

The Law of Diminishing Marginal Returns (LDMR) states that as successive units of a variable input are added to a fixed input, the marginal product of the variable input eventually declines. LDMR is a short-run phenomenon: it does not mean total output falls — TP keeps rising until $MP = 0$ — only that each additional worker contributes less than the last. In the figures below, MP peaks at the 8th worker (48 units), $MP = AP = 36$ units at the 12th worker, and TP reaches its maximum of 512 units at the 16th worker, where $MP = 0$.

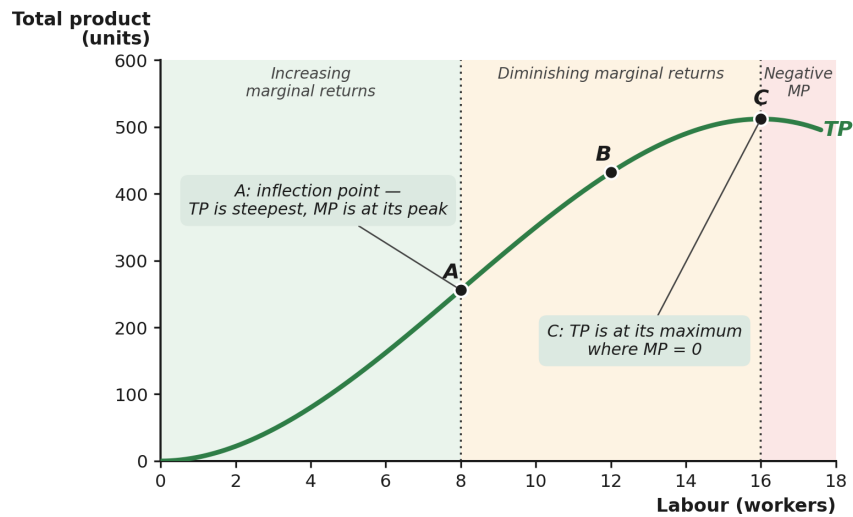


Figure 3.1a — Total Product. TP rises at an increasing rate up to the inflection point A ($L = 8$), then at a decreasing rate (diminishing marginal returns), and peaks at C ($L = 16$, $TP = 512$) where $MP = 0$.

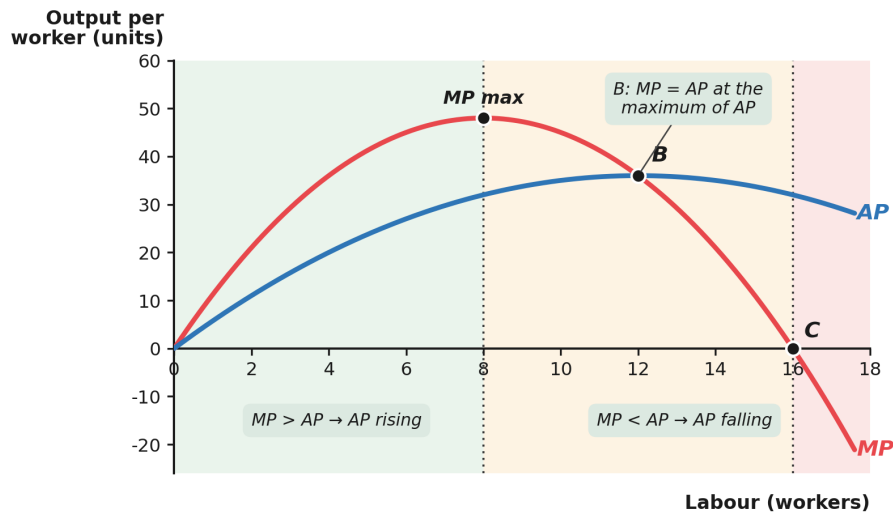


Figure 3.1b — Marginal and Average Product. MP peaks at $L = 8$ (point A on the TP curve), crosses AP at AP's maximum (B: $L = 12$, $MP = AP = 36$), and reaches zero at $L = 16$ (C).

★ AP Exam Tips — Topic 3.1

LDMR is not the same as negative returns. TP is still rising when MP is declining — TP only falls when MP becomes negative.

On FRQs, you are often asked to identify the range of L where LDMR has set in — it begins the moment MP starts to fall, not when TP falls.

MP = AP at AP's maximum: this is a mathematical identity, not a coincidence — be ready to explain it in words.

LDMR assumes technology and the fixed input are constant. An improvement in technology shifts the whole TP curve up and is not a violation of LDMR.

A common MCQ trap: which curve is higher at low levels of L? MP starts above AP and falls through it at AP's peak.

Key Terms — Topic 3.1

Production function	Relationship between inputs and maximum output.
Total product (TP)	Total output produced with a given amount of labour.
Marginal product (MP)	Extra output from one additional unit of labour ($\Delta TP/\Delta L$).
Average product (AP)	Output per unit of labour (TP/L).
Diminishing marginal returns	MP eventually falls as variable input increases with fixed capital.
Short run	Period in which at least one input is fixed.
Long run	Period in which all inputs can be varied.

TOPIC 3.2 — SHORT-RUN PRODUCTION COSTS

COLLEGE BOARD CED · ENDURING UNDERSTANDING PRD-1

Firms' production and cost constraints over different input and output levels shape optimal decisions in the short run and long run.

Learning Objective PRD-1.A

- Define (using graphs where appropriate) key terms and concepts relating to production and cost.
- Explain (using graphs where appropriate) how production and cost are related in the short run and long run.
- Calculate (using data from a graph or table as appropriate) the various measures of productivity and short-run and long-run costs.

Essential Knowledge

PRD-1.A.4 Fixed costs and variable costs determine the total cost.

PRD-1.A.5 Marginal cost, average (fixed, variable, and total) cost, total cost, and total variable cost change as total output changes, but total fixed cost remains constant at all output levels, including zero output.

PRD-1.A.6 Production functions with diminishing marginal returns yield an upward-sloping marginal cost curve.

PRD-1.A.7 Specialization and the division of labor reduce marginal costs for firms.

PRD-1.A.8 Cost curves can shift in response to changes in input costs and productivity.

Total Cost and Its Components

Short-run costs split into two categories. Fixed costs (FC) do not change with output — rent, insurance, and salaried staff are examples. Variable costs (VC) rise with output — raw materials and hourly wages. Total cost (TC) is their sum: $TC = FC + VC$. On a graph, the TC curve is the VC curve shifted up by the constant FC amount. Both TC and VC are S-shaped when the law of diminishing marginal returns applies.

$$TC = FC + VC$$

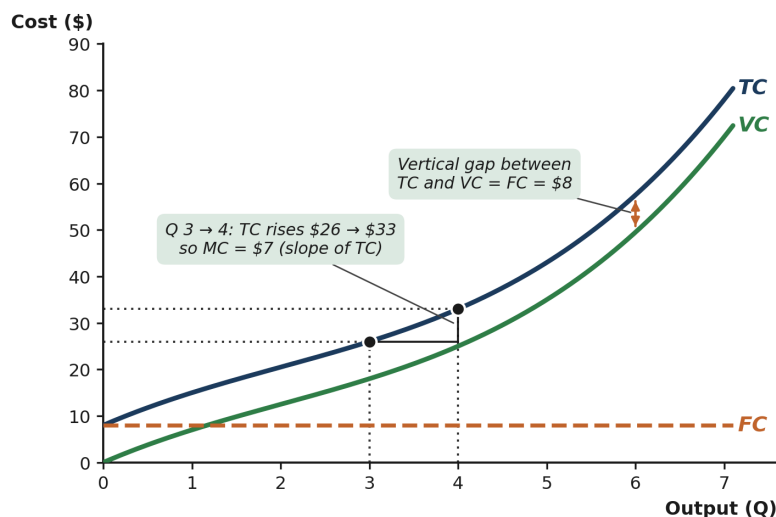


Figure 3.2a — TC, VC, and FC for our firm ($FC = \$8$). The vertical gap between TC and VC is always equal to FC. The slope of TC between two outputs is marginal cost: from $Q = 3$ to $Q = 4$, TC rises by \$7, so $MC = \$7$.

Per-Unit (Average) and Marginal Costs

Dividing total costs by output (Q) yields the per-unit cost curves. $ATC = TC/Q = AVC + AFC$. $AVC = VC/Q$. $AFC = FC/Q$ — always declining as Q rises. Marginal cost (MC) = $\Delta TC/\Delta Q$, the cost of producing one more unit. MC is the most important cost concept for pricing and output decisions.

$$MC = \Delta TC \div \Delta Q = \Delta VC \div \Delta Q \text{ (FC never changes, so } \Delta TC = \Delta VC \text{)}$$

The MC curve is U-shaped because of LDMP: when additional workers add a lot of output, MC is low; when MP is declining, it costs more per unit of output, so MC rises. MC intersects both AVC and ATC at their minimum points — a mathematical identity. ATC 's minimum lies to the right of AVC 's minimum because AFC pulls ATC down even after AVC begins rising.

Worked Example — Calculating MC and ATC

A firm has $FC = \$8$. Output rises from 3 to 4 units; VC rises from \$18 to \$25.

$$MC = \Delta VC/\Delta Q = (\$25 - \$18)/1 = \$7.$$

$$TC \text{ at } Q = 4: \$8 + \$25 = \$33. ATC = \$33/4 = \$8.25. AVC = \$25/4 = \$6.25. AFC = \$8/4 = \$2.00.$$

✓ Check: $AVC + AFC = \$6.25 + \$2.00 = ATC = \$8.25$. $Q = 4$ is also where ATC reaches its minimum (Figure 3.2b).

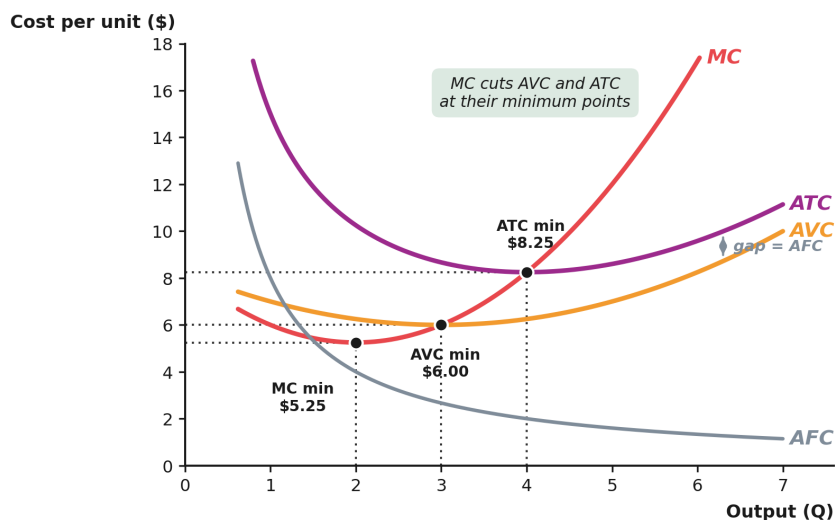


Figure 3.2b — MC , ATC , AVC , and AFC . MC is lowest at \$5.25 ($Q = 2$), then cuts AVC at its minimum (\$6, $Q = 3$) and ATC at its minimum (\$8.25, $Q = 4$). AFC declines throughout and equals the vertical gap between ATC and AVC .

Why MC Cuts ATC at Its Minimum

Think of ATC as your class average and MC as the next test score. A score below your average ($MC < ATC$) pulls the average down; a score above your average ($MC > ATC$) pulls it up. So ATC can only stop falling and start rising at the exact point where $MC = ATC$ — its minimum. The same logic explains why MC crosses AVC at AVC 's minimum.

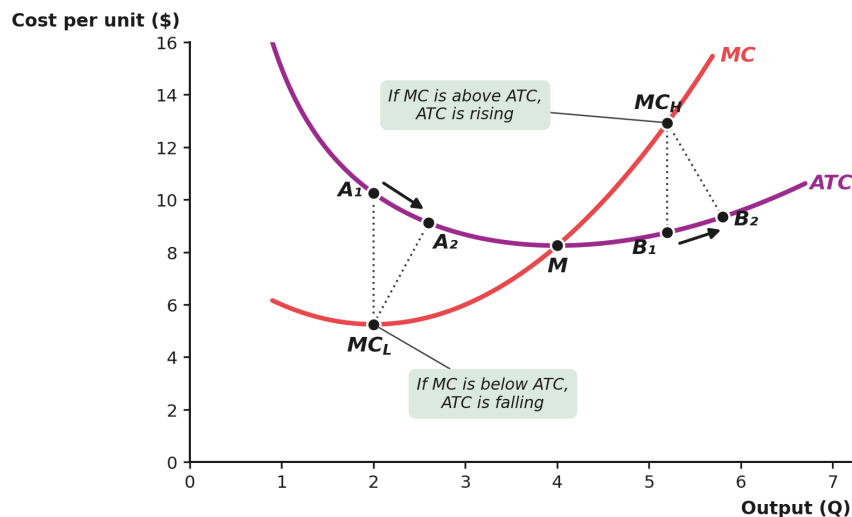


Figure 3.2c — MC below ATC pulls the average down ($A_1 \rightarrow A_2$); MC above ATC pulls the average up ($B_1 \rightarrow B_2$). ATC is at its minimum at M, where $MC = ATC$ (\$8.25 at $Q = 4$).

★ AP Exam Tips — Topic 3.2

MC intersects AVC and ATC at their minimum points. If MC is below ATC, ATC must still be falling; if MC is above ATC, ATC is rising.

AFC always falls because fixed cost is spread over more units. AFC never rises.

$ATC = AVC + AFC$. As $Q \rightarrow \infty$, ATC approaches AVC ($AFC \rightarrow 0$).

On FRQs, be able to draw all four curves correctly and explain why MC is U-shaped.

A shift in FC shifts ATC and AFC but not AVC or MC. A shift in VC shifts AVC, ATC, and MC.

Key Terms — Topic 3.2

Fixed cost (FC)	Cost that does not vary with output (e.g. rent).
Variable cost (VC)	Cost that rises with output (e.g. materials, hourly wages).
Marginal cost (MC)	$\Delta TC / \Delta Q$; cost of one more unit of output.
Average total cost (ATC)	TC / Q ; total cost per unit.
Average variable cost (AVC)	VC / Q ; variable cost per unit.
Average fixed cost (AFC)	FC / Q ; always declining.

TOPIC 3.3 — LONG-RUN PRODUCTION COSTS

COLLEGE BOARD CED · ENDURING UNDERSTANDING PRD-1

Firms' production and cost constraints over different input and output levels shape optimal decisions in the short run and long run.

Learning Objective PRD-1.A

- Define (using graphs where appropriate) key terms and concepts relating to production and cost.
- Explain (using graphs where appropriate) how production and cost are related in the short run and long run.
- Calculate (using data from a graph or table as appropriate) the various measures of productivity and short-run and long-run costs.

Essential Knowledge

PRD-1.A.9 In the long run, firms can adjust all their inputs, and as a result, all costs become variable.

PRD-1.A.10 The relationship between inputs and outputs in the long run is described by the scale of production—increasing, decreasing, or constant returns to scale.

PRD-1.A.11 The long-run average total cost is characterized by economies of scale, diseconomies of scale, or constant returns to scale (efficient scale).

PRD-1.A.12 The minimum efficient scale plays a role in determining the concentration of firms in a market and the market structure.

The Long Run: All Inputs Variable

In the long run, a firm can adjust all inputs, including plant size. Each possible plant size has its own short-run ATC (SRATC) curve. The long-run average total cost curve (LRATC) is the lower envelope of all these SRATC curves — it shows the minimum ATC achievable for each output level when the firm can choose the optimal plant size. Because there are no fixed inputs in the long run, the LRATC may be lower than any individual SRATC.

Economies and Diseconomies of Scale

Economies of scale occur when LRATC falls as output expands — larger firms can specialise labour, spread overhead, and use more efficient capital. Diseconomies of scale occur when LRATC rises with output — coordination costs and managerial overstretch become the bottleneck at very large scales. Constant returns to scale is the flat middle range where LRATC is approximately constant. The output level at the bottom of the LRATC is the minimum efficient scale (MES) — the smallest scale at which a firm exhausts economies of scale.

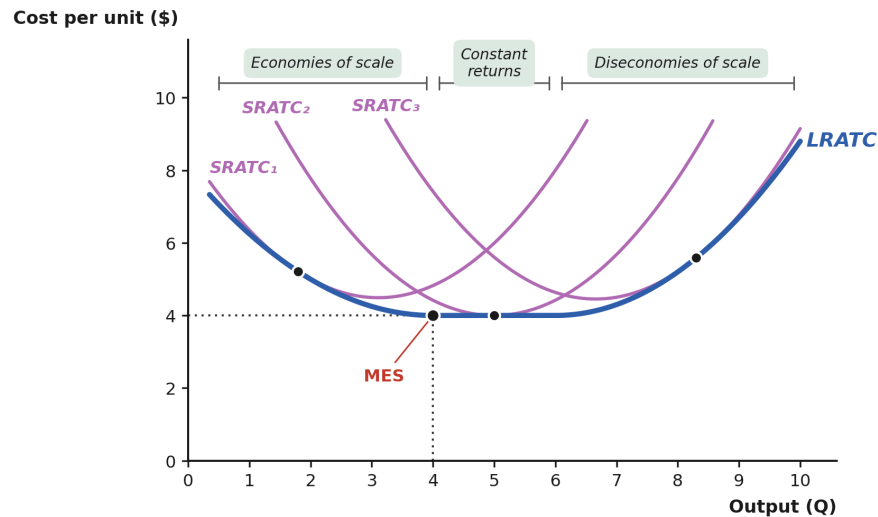


Figure 3.3 — LRATC as the envelope of SRATC curves. Each SRATC touches LRATC at exactly one point (dots). MES is at $Q = 4$, $ATC = \$4$, where LRATC first reaches its minimum. LRATC falls under economies of scale, is flat at constant returns ($Q = 4$ – 6), and rises under diseconomies of scale.

♪ Real-World Example — Grocery Retail

A single corner store has a high LRATC because it buys inventory at retail prices and pays a small-business rent premium.

A regional supermarket chain achieves economies of scale through bulk purchasing discounts, shared logistics, and centralised accounting.

A global retailer like Walmart may face some diseconomies — managing thousands of locations adds coordination costs that can push average costs back up.

MES for grocery retail is typically reached at a mid-sized regional footprint.

★ AP Exam Tips — Topic 3.3

LRATC is U-shaped for the same reason as SRATC, but the mechanism differs: SRATC rises because of diminishing returns to a fixed input; LRATC rises because of diseconomies of scale.

Each SRATC is tangent to LRATC at exactly one point. A firm on LRATC is at its optimal long-run plant size for that output level.

MES matters for market structure: when MES is very large relative to total market demand, few firms can fit — a natural monopoly may result.

Do not confuse economies of scale (long run, all inputs vary) with increasing marginal returns (short run, one input fixed). The AP exam distinguishes them in FRQs.

Key Terms — Topic 3.3

Long-run ATC (LRATC)	Envelope of all SRATC curves; minimum cost for each Q when all inputs vary.
Economies of scale	LRATC falls as output expands.
Diseconomies of scale	LRATC rises as output expands.
Constant returns to scale	LRATC is flat; doubling inputs doubles output.
Minimum efficient scale (MES)	Smallest output at which LRATC reaches its minimum.

TOPIC 3.4 — TYPES OF PROFIT

COLLEGE BOARD CED · ENDURING UNDERSTANDING CBA-2

To determine the optimal level at which to pursue an activity whose total benefits exceed total cost, rational economic agents compare marginal benefits and marginal costs.

Learning Objective CBA-2.C

- a. Define the different types of profit.
- b. Explain how firms respond to profit opportunities.
- c. Calculate a firm's profit or loss.

Essential Knowledge

CBA-2.C.1 Firms respond to economic profit (loss) rather than accounting profit.

CBA-2.C.2 Accounting profit fails to account for implicit costs (such as cost of financial capital, compensation for risk, or an entrepreneur's time), which, if fully compensated, result in normal profit.

Explicit and Implicit Costs

Economics distinguishes two types of costs. Explicit costs are direct, out-of-pocket payments for inputs — wages paid, rent, and material costs. Implicit costs are the opportunity costs of self-owned resources used in production — the salary an owner-operator forgoes by not working elsewhere, or the return on equity capital forgone by not investing it. Economists insist on including both because every decision involves an opportunity cost, even if no cash changes hands.

Accounting Profit vs. Economic Profit

Accounting profit = Total Revenue – Explicit Costs. This is the number on a firm's income statement. Economic profit = TR – Explicit Costs – Implicit Costs = Accounting profit – Implicit costs. Economic profit is therefore always less than or equal to accounting profit. When economic profit = 0, the firm earns a normal profit — exactly enough to cover all explicit and implicit costs. A firm earning zero economic profit has no incentive to exit.

$$\text{Accounting Profit} = \text{TR} - \text{Explicit Costs}$$

$$\text{Economic Profit} = \text{TR} - \text{Explicit Costs} - \text{Implicit Costs}$$

Worked Example — Accounting vs. Economic Profit

Maya quits a \$60,000/yr job to open a bakery. Revenue: \$200,000. Explicit costs (rent, ingredients, staff): \$130,000.

Accounting profit = \$200,000 – \$130,000 = \$70,000.

Implicit cost = forgone salary = \$60,000.

Economic profit = \$70,000 – \$60,000 = \$10,000. Maya is better off in the bakery than her next-best option.

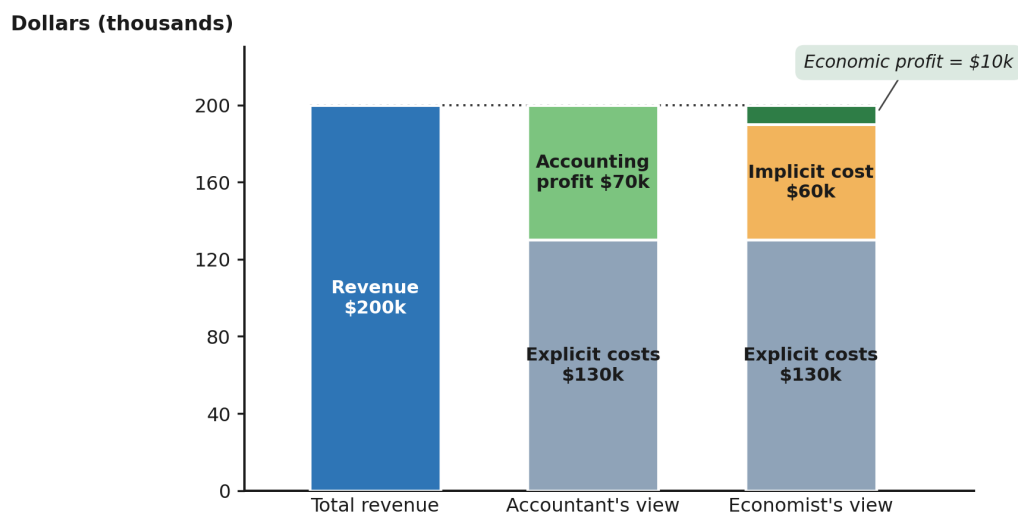


Figure 3.4 — Maya's bakery. The accountant subtracts only explicit costs (\$70k accounting profit). The economist also subtracts the \$60k implicit cost (Maya's forgone salary), leaving \$10k of economic profit.

✎ Worked Example — Normal Profit

If Maya's revenue were only \$190,000 (other costs unchanged): accounting profit = \$60,000.

Economic profit = \$60,000 - \$60,000 = \$0.

Maya earns a normal profit. She has no reason to exit — the bakery pays exactly as well as her next-best option.

★ AP Exam Tips — Topic 3.4

Zero economic profit $\neq$ zero accounting profit. "Normal profit" always means zero economic profit on the AP exam.

Economic profit < 0 signals resources are better used elsewhere. Firms exit in the long run until economic profit returns to zero.

Economic profit > 0 attracts new entrants, which increases market supply, lowers price, and erodes profit until it returns to zero (in perfect competition).

A common FRQ phrase: "The firm is earning a normal profit, so there is no incentive to enter or exit." Know this wording.

Key Terms — Topic 3.4

Explicit cost	Out-of-pocket payment for an input (wages, rent, materials).
Implicit cost	Opportunity cost of self-owned resources used in production.
Accounting profit	TR minus explicit costs.
Economic profit	TR minus all costs (explicit + implicit).
Normal profit	Zero economic profit; all costs including opportunity cost are covered.

TOPIC 3.5 — PROFIT MAXIMISATION

COLLEGE BOARD CED · ENDURING UNDERSTANDING CBA-2

To determine the optimal level at which to pursue an activity whose total benefits exceed total cost, rational economic agents compare marginal benefits and marginal costs.

Learning Objective CBA-2.D

- a. Define (using graphs or data as appropriate) the profit-maximizing rule.
- b. Explain (using a graph or data as appropriate) the profit-maximizing level of production.

Essential Knowledge

CBA-2.D.1 Firms are assumed to produce output to maximize their profits by comparing marginal revenue and marginal cost.

The MR = MC Rule

A profit-maximising firm produces the output level where marginal revenue (MR) equals marginal cost (MC). Intuition: if $MR > MC$, producing one more unit adds more to revenue than to cost — profit rises, so produce more. If $MR < MC$, the last unit costs more than it earns — produce less. Profit is maximised at the exact quantity Q^* where $MR = MC$. This rule holds for every market structure — the only difference is how MR is calculated.

Profit-Maximising Q^* : $MR = MC$

Profit = $(P - ATC) \times Q^*$ [area of the profit rectangle]

Reading the Diagram

On a cost-curve diagram, find Q^* where the MC curve crosses the MR line (= P in perfect competition). Read up from Q^* to the price line to find P; read up to the ATC curve to find ATC at Q^* . If $P > ATC$: economic profit — shade the rectangle $(P - ATC) \times Q^*$ in green. If $AVC < P < ATC$: economic loss — shade $(ATC - P) \times Q^*$ in orange; the firm still produces because it covers variable costs and contributes to fixed costs.

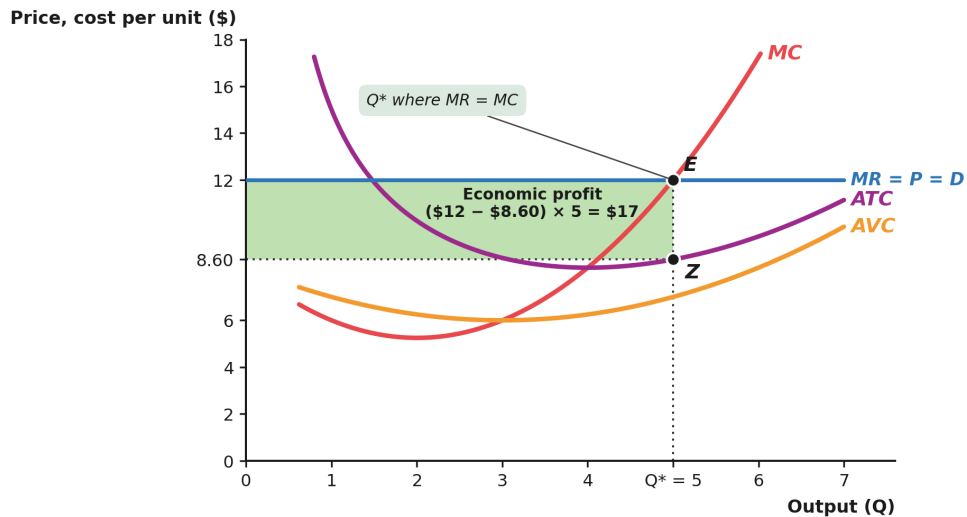


Figure 3.5a — $P = \$12 > ATC$. $MR = MC$ at E gives $Q^* = 5$. ATC at Q^* is $\$8.60$ (point Z), so the firm earns an economic profit of $(\$12 - \$8.60) \times 5 = \$17$ (green rectangle).

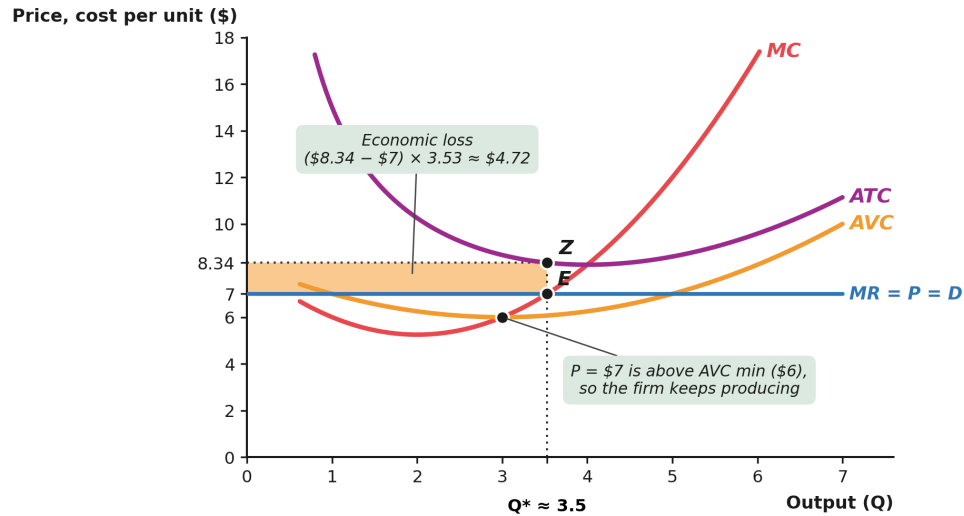


Figure 3.5b — $AVC < P = \$7 < ATC$. $MR = MC$ at $Q^* \approx 3.5$; ATC there is $\approx \$8.34$, so the firm makes an economic loss of about $\$4.72$ (orange rectangle) — but it keeps producing because P is above min AVC ($\$6$).

✎ Worked Example — Profit Calculation

A perfectly competitive firm faces $P = \$12$. At $Q^* = 5$ (where $MR = MC$): $ATC = \$8.60$, $AVC = \$7.00$.

$Profit = (P - ATC) \times Q^* = (\$12 - \$8.60) \times 5 = \$17$.

If P fell to $\$7$: find Q^* where $MC = \$7$ ($Q^* \approx 3.53$). ATC at $Q^* \approx \$8.34$.

$Loss = (\$7 - \$8.34) \times 3.53 \approx -\$4.72$. Since $P = \$7 > AVC \text{ min} = \$6$, the firm produces rather than shuts down — shutting down would lose the full FC of $\$8$.

★ AP Exam Tips — Topic 3.5

MR = MC is the universal profit-maximisation rule. Never say “maximise ATC” or “maximise TR” — those are common wrong answers.

In perfect competition, $P = MR = AR = D$ for the firm. The MR line is the same as the horizontal demand/price line.

The profit rectangle has height $(P - ATC)$ and base Q^* . If $P < ATC$, the rectangle is a loss rectangle and lies above the price line.

On FRQs, always label Q^* , P , and ATC at Q^* on your diagram before drawing the rectangle.

Economic profit = 0 is also possible: when the MR line just touches the minimum of the ATC curve — this is long-run equilibrium in perfect competition.

Key Terms — Topic 3.5

Marginal revenue (MR)	Extra revenue from selling one more unit ($\Delta TR/\Delta Q$).
Profit-maximising Q^*	Output where $MR = MC$.
Economic profit	$(P - ATC) \times Q^*$; can be positive, zero, or negative.
Profit rectangle	On a diagram: height = $P - ATC$, base = Q^* .
Loss rectangle	On a diagram: height = $ATC - P$, base = Q^* (when $P < ATC$).

TOPIC 3.6 — FIRMS' SHORT-RUN DECISIONS

COLLEGE BOARD CED · ENDURING UNDERSTANDING PRD-2

Firms' short-run decisions to produce output, and long-run decisions to enter or exit a market, are based on profitability.

Learning Objective PRD-2.A

Explain (using graphs or data where appropriate) firms' short-run decisions to produce positive output levels, or long-run decisions to enter or exit a market in response to profit-making opportunities.

Essential Knowledge

PRD-2.A.1 In the short run, firms decide to operate (i.e., produce positive output) or shut down (i.e., produce zero output) by comparing total revenue to total variable cost or price to average variable cost (AVC).

PRD-2.A.2 In the absence of barriers to entry or exit, in the long run (i.e., once factors that are fixed in the short run become variable), firms enter a market in which there are profit-making opportunities and exit a market when they anticipate economic losses.

The Shutdown Rule

In the short run a firm cannot eliminate its fixed costs — if it stops producing, it still pays FC (rent, loan payments). The question is whether producing generates enough revenue to cover at least the variable costs. The shutdown rule: a firm should shut down in the short run if $P < AVC$. When $P < AVC$, every unit produced loses more than the fixed cost per unit, so shutting down minimises the loss to just FC. When $P \geq AVC$, producing reduces the total loss below FC because revenue covers variable costs and contributes something toward fixed costs.

Break-Even and Shutdown Prices

Two critical price thresholds appear on the cost diagram. The break-even price is where $P = ATC$ at its minimum. At this price, economic profit = 0 (normal profit). The shutdown price is where $P = AVC$ at its minimum. Below this price, the firm shuts down. Between the shutdown and break-even prices, the firm produces but earns an economic loss — it continues because covering some fixed costs is better than covering none.

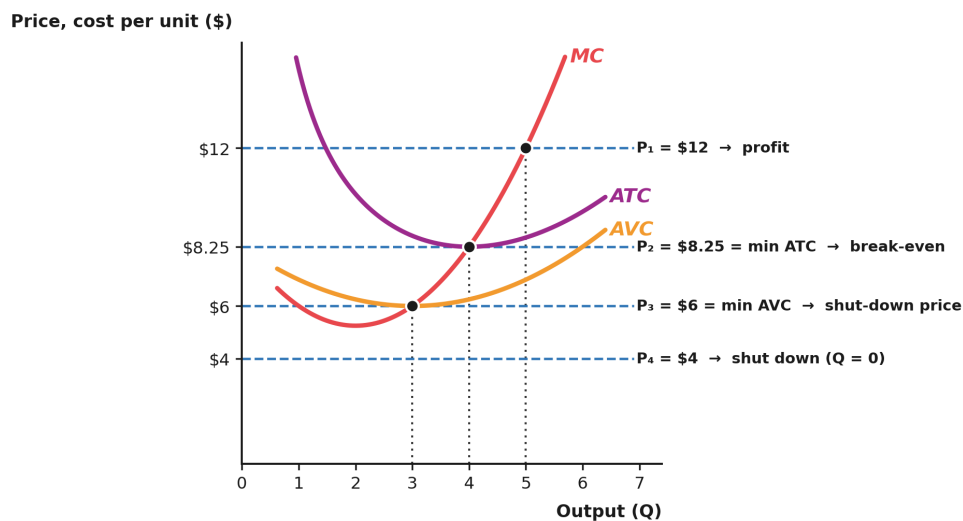


Figure 3.6a — Four price scenarios for our firm. P_1 (\$12) → economic profit. P_2 (\$8.25 = min ATC) → break-even. P_3 (\$6 = min AVC) → shutdown price. P_4 (\$4 < min AVC) → shut down.

Price Condition	Short-Run Decision	Economic Result
$P > ATC \text{ min}$	Produce at $MR = MC$	<i>Economic profit</i>
$P = ATC \text{ min}$	Produce at $MR = MC$	<i>Normal profit (zero economic profit)</i>
$AVC \text{ min} < P < ATC \text{ min}$	Produce at $MR = MC$	<i>Economic loss; loss < FC</i>
$P = AVC \text{ min}$	Indifferent; produce or shut down	<i>Loss = FC either way</i>
$P < AVC \text{ min}$	Shut down	<i>Loss = FC (smaller than producing)</i>

The Firm's Short-Run Supply Curve

Because the firm produces where $P = MC$ whenever $P \geq \min AVC$, its MC curve tells us how much it will supply at every price. The firm's short-run supply curve is therefore the portion of its MC curve at and above min AVC. For our firm: at \$6 it supplies 3 units, at \$8.25 it supplies 4, and at \$12 it supplies 5. Below \$6 it shuts down and supplies zero.

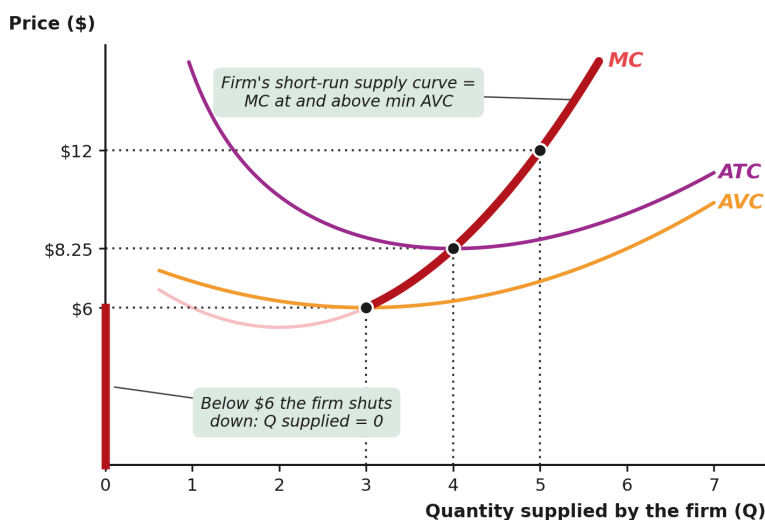


Figure 3.6b — The firm's short-run supply curve (bold red): the MC curve at and above min AVC (\$6). Below the shutdown price, quantity supplied is zero (along the vertical axis).

★ AP Exam Tips — Topic 3.6

The shutdown rule compares P to AVC , not ATC . Fixed costs are irrelevant to the shutdown decision because they are sunk in the short run.

The short-run supply curve for a perfectly competitive firm is the portion of its MC curve above AVC min. Below that price the firm shuts down and supplies zero.

“Shut down” $\neq$ “exit.” Shutdown is a short-run decision (firm still exists, pays FC); exit is long-run (firm leaves the industry entirely).

In the long run, the exit condition is $P < ATC$ min (economic loss). There are no fixed costs in the long run, so the firm exits whenever it cannot cover all costs.

FRQ tip: always state both the condition and the reasoning. E.g.: “Since $P < AVC$, the firm shuts down because revenue does not cover variable costs.”

Key Terms — Topic 3.6

Shutdown rule	Shut down in the short run if $P < AVC$ min.
Shutdown price	Price equal to minimum AVC ; firm is indifferent between producing and shutting down.
Break-even price	Price equal to minimum ATC ; firm earns zero economic profit.
Sunk cost	A cost already incurred that cannot be recovered; fixed costs are sunk in the short run.
Short-run supply curve	The MC curve above AVC min for a perfectly competitive firm.

TOPIC 3.7 — PERFECT COMPETITION

COLLEGE BOARD CED · ENDURING UNDERSTANDING PRD-3

Even with a common goal of profit-maximization, market structure constrains and influences prices, output, and efficiency.

Learning Objective PRD-3.A

- a. Define (using graphs as appropriate) the characteristics of perfectly competitive markets and efficiency.
- b. Explain (using graphs where appropriate) equilibrium and firm decision making in perfectly competitive markets and how prices in perfectly competitive markets lead to efficient outcomes.
- c. Calculate (using data from a graph or table as appropriate) economic profit (loss) in perfectly competitive markets.

Essential Knowledge

- PRD-3.A.1 A perfectly competitive market is efficient. Firms in perfectly competitive markets face no barriers to entry and have no market power.
- PRD-3.A.2 In perfectly competitive markets, prices communicate to consumers and producers the magnitude of others' marginal costs of production and marginal benefits of consumption and provide incentives to act on that information (i.e., price equals marginal cost in an efficient market).
- PRD-3.A.3 In perfectly competitive markets, firms can sell all their outputs at a constant price determined by the market.
- PRD-3.A.4 At a competitive market equilibrium, firms are price takers and select output to maximize profit by producing the level of output where the marginal cost equals marginal revenue (at the price).
- PRD-3.A.5 At a competitive market equilibrium, the price of a product equals both the private marginal benefit received by the last unit consumed and the private marginal cost incurred to produce the last unit, thus achieving allocative efficiency.
- PRD-3.A.6 In a short-run competitive equilibrium, price can either be above or below its long-run competitive level resulting in profits or losses, motivating entry or exit of firms and moving prices and quantities toward long-run equilibrium.
- PRD-3.A.7 In a long-run perfectly competitive equilibrium, productive efficiency implies all operating firms produce at efficient scale, price equals marginal cost and minimum average total cost, and firms earn zero economic profit.
- PRD-3.A.8 Firms may be in a constant cost, increasing cost, or decreasing cost industry. Long-run prices depend on the portion of the long-run cost curves on which firms operate.
- PRD-3.A.9 A perfectly competitive market in long-run equilibrium is allocatively and productively efficient.

Characteristics of Perfect Competition

A perfectly competitive market has four defining features: (1) Many buyers and sellers — no single agent influences price. (2) Identical (homogeneous) products — buyers have no preference between sellers. (3) Perfect information — all participants know prices and quality. (4) Free entry and exit — no barriers prevent new firms from entering or leaving. As a result, each firm is a price taker: it accepts the market price as given and faces a perfectly elastic (horizontal) demand curve at that price.

Short-Run and Long-Run Equilibrium

In the short run, a perfectly competitive firm produces at Q^* where $P = MR = MC$. Economic profits or losses are possible. In the long run, free entry and exit drives economic profit to zero. If the industry earns profit $\rightarrow$ new firms enter $\rightarrow$ market supply rises $\rightarrow$ price falls until $P = ATC \min$

and economic profit = 0. If the industry suffers loss $\rightarrow$ firms exit $\rightarrow$ supply falls $\rightarrow$ price rises until $P = ATC$ min. Long-run equilibrium therefore requires: $P = MR = MC = ATC$ min. The firm operates at minimum ATC (productive efficiency) and $P = MC$ (allocative efficiency).

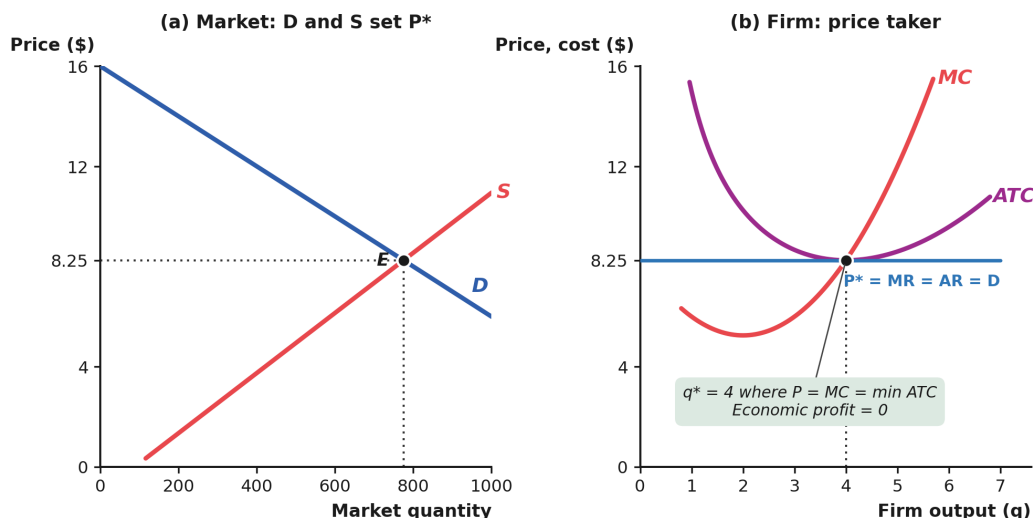


Figure 3.7a — Left: the industry market sets $P^* = \$8.25$. Right: the individual firm takes P^* as $MR = AR = D$ and produces $q^* = 4$, where $P = MC = \min ATC$ — zero economic profit in long-run equilibrium.

How Entry Eliminates Economic Profit

Suppose the market starts at E_1 with price \$12. Each firm produces 5 units and earns \$17 of economic profit (Topic 3.5). That profit attracts new firms: entry shifts market supply right from S_1 to S_2 , and the price falls. Entry continues until the price reaches $\$8.25 = \min ATC$ at E_2 . Each firm now produces 4 units and earns zero economic profit, so there is no further incentive to enter or exit. (If price started below $\$8.25$, exit would shift supply left and push the price back up to $\$8.25$.)

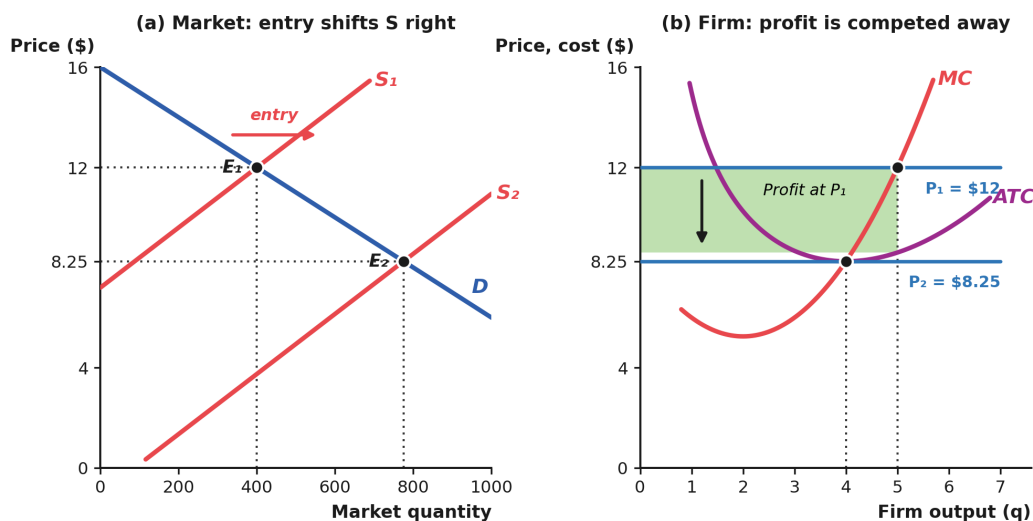


Figure 3.7b — Left: entry shifts market supply from S_1 to S_2 , lowering price from \$12 (E_1) to \$8.25 (E_2). Right: the firm's green profit rectangle at P_1 disappears; at $P_2 = \min ATC$ the firm earns zero economic profit.

♪ **Real-World Approximation — Agricultural Markets**

Canadian wheat farmers approximate perfect competition: thousands of farms sell an identical commodity and prices are set on global exchanges (no individual farm influences the world wheat price).

When wheat prices rise above average cost, more land is planted — supply rises and price settles back toward the break-even level.

The long-run trend of falling real agricultural prices in competitive commodity markets reflects this entry-and-adjustment process at work.

Condition	What It Means	Efficiency Concept
$P = MC$	Price equals marginal cost; the last unit's value equals its social cost	<i>Allocative efficiency</i>
$P = ATC \text{ min}$	Production at minimum average total cost; no productive waste	<i>Productive efficiency</i>
Economic $\pi = 0$	Normal profit; no excess returns to attract entry or trigger exit	<i>Long-run equilibrium</i>

★ **AP Exam Tips — Topic 3.7**

In long-run perfect competition, $P = MR = MC = ATC \text{ min}$. This “magic equality” is a favourite FRQ condition — know it cold.

The demand curve for an individual perfectly competitive firm is horizontal at the market price. Do not draw it downward-sloping.

Entry increases market supply (shifts S right), lowers price, and eliminates economic profit. Draw the shift on the industry diagram, then show the lower P line on the firm diagram.

Perfectly competitive firms are both productively efficient ($P = \text{min ATC}$) and allocatively efficient ($P = MC$). Monopoly achieves neither — a common FRQ contrast.

Perfect competition rarely exists in pure form, but it is the theoretical benchmark for economic efficiency on the AP exam.

Key Terms — Topic 3.7

Price taker	A firm that accepts the market price as given; faces horizontal demand.
Homogeneous product	Identical goods across all sellers; buyers have no preference.
Free entry and exit	No barriers; firms enter when profits positive, exit when losses occur.
Long-run equilibrium	$P = MR = MC = ATC \text{ min}$; economic profit = 0.
Allocative efficiency	$P = MC$; resources directed to their highest-valued use.
Productive efficiency	Production at minimum ATC; no resource waste.

UNIT 3 QUICK REFERENCE SUMMARY

Topic	Key Formula / Concept	Graphical Signature	Key Terms to Remember
3.1 The Production Function	$MP = \Delta TP / \Delta L$ $AP = TP / L$ Law of Diminishing Marginal Returns	TP: S-shaped MP: inverted-U $MP = AP$ at AP maximum	Total product, marginal product, average product, LD MR
3.2 Short-Run Costs	$TC = FC + VC$ $MC = \Delta TC / \Delta Q$ $ATC = AVC + AFC$	MC crosses AVC & ATC at minima AFC always declining All U-shaped except AFC	Fixed cost, variable cost, MC, ATC, AVC, AFC
3.3 Long-Run Costs	LRATC = envelope of all SRATC curves MES = bottom of LRATC	U-shaped LRATC: EoS CRS DoS	LRATC, economies of scale, diseconomies, MES
3.4 Types of Profit	Economic profit = $TR - (\text{explicit} + \text{implicit})$ Normal profit: economic profit = 0	Stacked bar: revenue vs. explicit + implicit costs	Explicit/implicit cost, accounting profit, normal profit
3.5 Profit Maximisation	Produce where $MR = MC$ Profit = $(P - ATC) \times Q^*$	MC crosses $MR = P$ line at Q^* Rectangle above/below ATC	Marginal revenue, Q^* , profit/loss rectangle
3.6 Short-Run Decisions	Shut down if $P < AVC \text{ min}$ Break-even if $P = ATC \text{ min}$	MC above AVC min = supply curve Four price zones on cost diagram	Shutdown price, break-even, shut down vs. exit, sunk cost
3.7 Perfect Competition	Long run: $P = MR = MC = ATC \text{ min}$ Economic profit = 0	Industry: D/S sets P^* Firm: horizontal D; $\pi = 0$ at ATC min Entry shifts S right	Price taker, free entry/exit, allocative & productive efficiency