# Lecture 13

## Cost Curves

# Review: Returns-to-Scale and AC

**The returns-to-scale properties of a firm's technology determine how average production costs change with output level（规模报酬决定平均成本如何随产出变化而变化）.**

# Review: Returns-to-Scale and AC

**If a firm's technology exhibits constant returns-to-scale then average production cost does not change.**

规模报酬不变时，平均成本不随产出变化而变化。

# Review: Returns-to-Scale and AC

**If a firm's technology exhibits constant returns-to-scale then average production cost does not change.**

规模报酬不变时，平均成本不随产出变化而变化。

**If $(x_1, x_2)$ minimizes the cost of producing y, with minimized costs being C, then**
**$(kx_1, kx_2)$ minimizes the cost of producing ky, with min cost being kC ($AC$ is constant)**

# Review: Returns-to-Scale and AC

**If a firm's technology exhibits increasing returns-to-scale then average production cost decreases.**

规模报酬递增时，平均成本随产出的上升而下降。

# Review: Returns-to-Scale and AC

**If a firm's technology exhibits increasing returns-to-scale then average production cost decreases.**

规模报酬递增时，平均成本随产出的上升而下降。

**If $(x_1, x_2)$ minimizes the cost of producing y, with minimized costs being C, then $(k'x_1, k'x_2)$ minimizes the cost of producing ky, with the min cost being $k'C < kC$ ($AC \downarrow$, under homotheticity)**

# Review: Returns-to-Scale and AC

**If a firm’s technology exhibits decreasing returns-to-scale then average production cost increases.**

规模报酬递减时，平均成本随产出的上升而上升。

# Review: Returns-to-Scale and AC

**If a firm's technology exhibits decreasing returns-to-scale then average production cost increases.**

规模报酬递减时，平均成本随产出的上升而上升。

**If $(x_1, x_2)$ minimizes the cost of producing y, with minimized costs being $C$, then $(k'x_1, k'x_2)$ minimizes the cost of producing ky, with the min cost being $k'C > kC$ ($AC\uparrow$, under homotheticity)**

# Review: Returns-to-Scale and AC

规模报酬递减时，平均成本随产出的上升而上升。

**Proof (without homotheticity):**

**Suppose $(x_1, x_2)$ minimizes the cost of producing y output units, with the minimized cost being $C$.**

**Assume $(x_1', x_2')$ minimizes the cost of producing ky output units, with the min cost being $C' \le kC$ (i.e. AC ↓)**

# Review: Returns-to-Scale and AC

**Assume** $(x_1', x_2')$ **minimizes the cost of producing** **ky** **output units, with the minimized cost being** $\boldsymbol{C' \leq kC}$ **(i.e. AC ↓)**

**Then the cost of** $\left(\frac{x_1'}{k}, \frac{x_2'}{k}\right)$ **is** $\frac{C'}{k} \leq$ **C.**

**Because the technology exhibits DRS, we know** $f\left(\frac{x_1'}{k}, \frac{x_2'}{k}\right) > y$**.**

# Review: Returns-to-Scale and AC

**The cost of $\left(\frac{x_1'}{k}, \frac{x_2'}{k}\right)$ is $\frac{C'}{k} \leq$ C.**

**Because the technology exhibits DRS, $f\left(\frac{x_1'}{k}, \frac{x_2'}{k}\right) > y$.**

**They contradict the fact that C is the minimized costs of producing y output units.**

# Review: Returns-to-Scale and AC

Therefore,

if $(x_1, x_2)$ minimizes the cost of producing y output units, with the minimized cost being $C$

And $(x_1', x_2')$ minimizes the cost of producing ky output units.

The cost of $(x_1', x_2')$ must be $> kC$ (i.e. AC must increase as y increases)

# Review: Cost Minimization

**Given y, the firm is to find the optimal input bundle that minimizes the production costs**

$$\min_{x_1, x_2} C = \omega_1 x_1 + \omega_2 x_2$$

$$\text{s.t. } f(x_1, x_2) = y$$

**The least-costly input bundle $x_1^*(\omega_1, \omega_2, y)$ and $x_2^*(\omega_1, \omega_2, y)$ are the firm's conditional demands for inputs 1 and 2**

# Review: Cost Minimization

**Given y, the firm is to find the optimal input bundle that minimizes the production costs**

$$\min_{\mathbf{x_1,x_2}} \mathbf{C = \omega_1 x_1 + \omega_2 x_2}$$

$$\textbf{s.t. } f(x_1, x_2) = y$$

**The total cost function is the smallest possible total cost for producing y output units**

$$\mathbf{C^* = \omega_1 x_1^* + \omega_2 x_2^*} = C(y)$$

# Review: Cost Minimization

**In the short run, $\mathbf{x_2 = \tilde{x}_2}$, the firm's problem becomes**

$$\min_{\mathrm{x}_1} \mathrm{C} = \omega_1 \mathrm{x}_1 + \omega_2 \tilde{x}_2$$

$$\text{s.t. } f(x_1, \tilde{x}_2) = y$$

**The total cost function can be expressed as**

$$\underbrace{C(y)}_{\text{总成本}} = \omega_1 \mathrm{x}_1^*(\mathrm{y}) + \omega_2 \tilde{x}_2 = \underbrace{C_v(y)}_{\text{可变成本}} + \underbrace{F}_{\text{固定成本}}$$

# Types of Cost Curves

A **total cost curve** is the graph of a firm's total cost function 总成本曲线, $C(y)$

A **variable cost curve** is the graph of a firm's variable cost function可变成本曲线, $C_v(y)$

A **fixed cost curve** is the graph of a firm's fixed cost function 固定成本曲线, $FC(y) = F$

# Types of Cost Curves

**average total cost curve** 平均成本曲线，$\mathrm{ATC}(y) = C(y)/y$

**average variable cost curve** 平均可变成本曲线，$AVC(y) = C_v(y)/y$

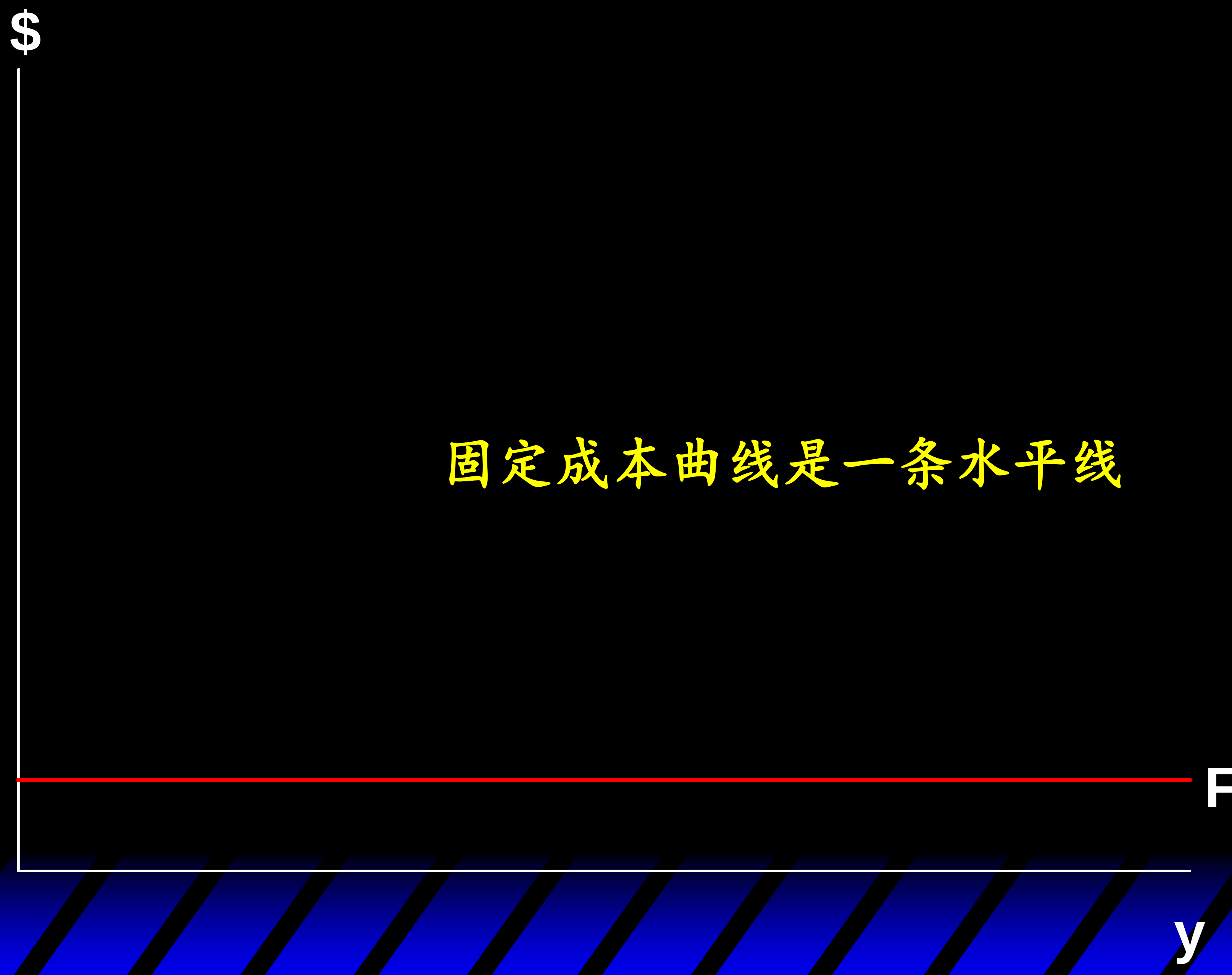
**average fixed cost curve** 平均固定成本曲线，$AFC(y) = F/y$

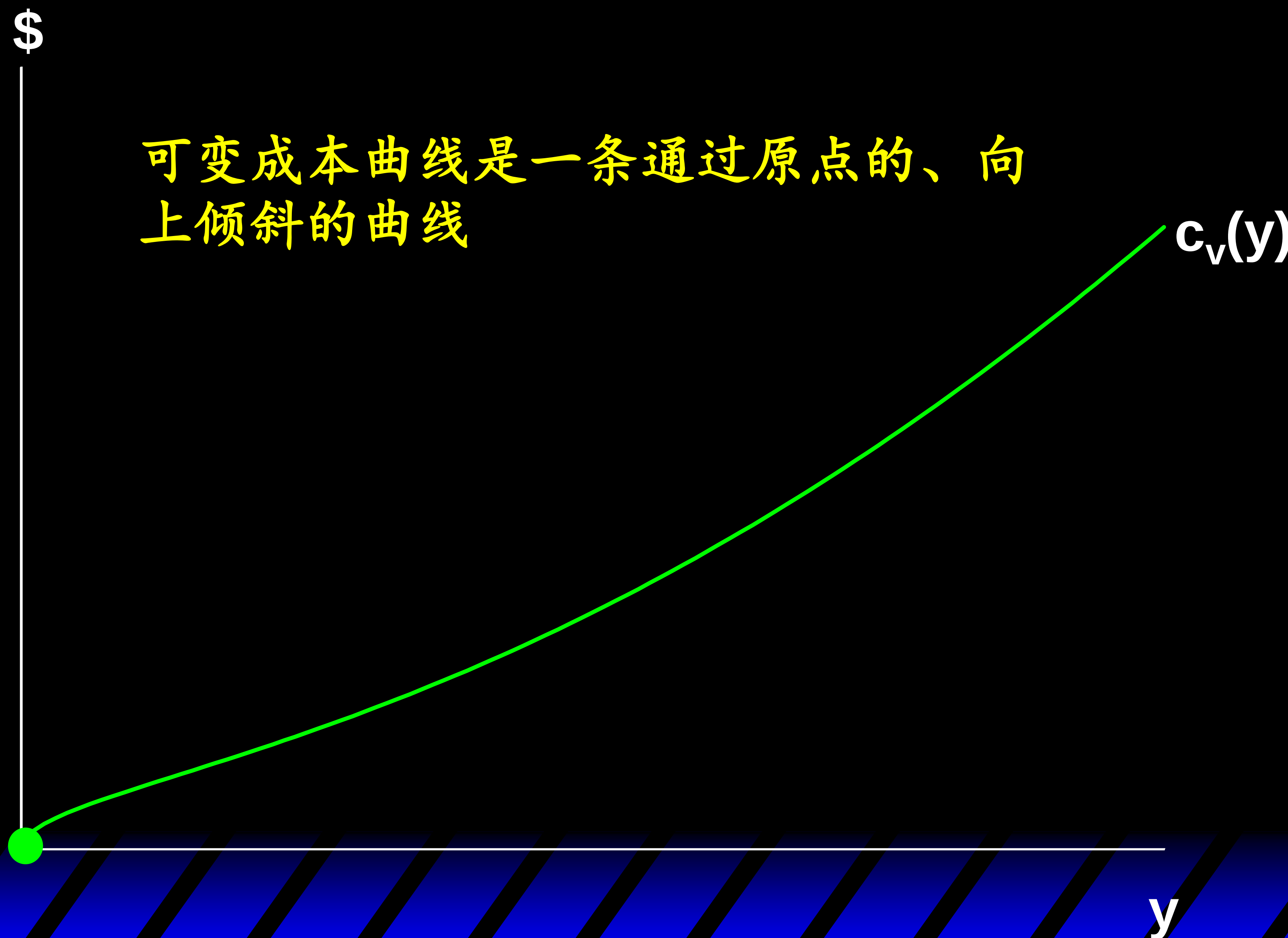
**marginal cost curve** 边际成本曲线，

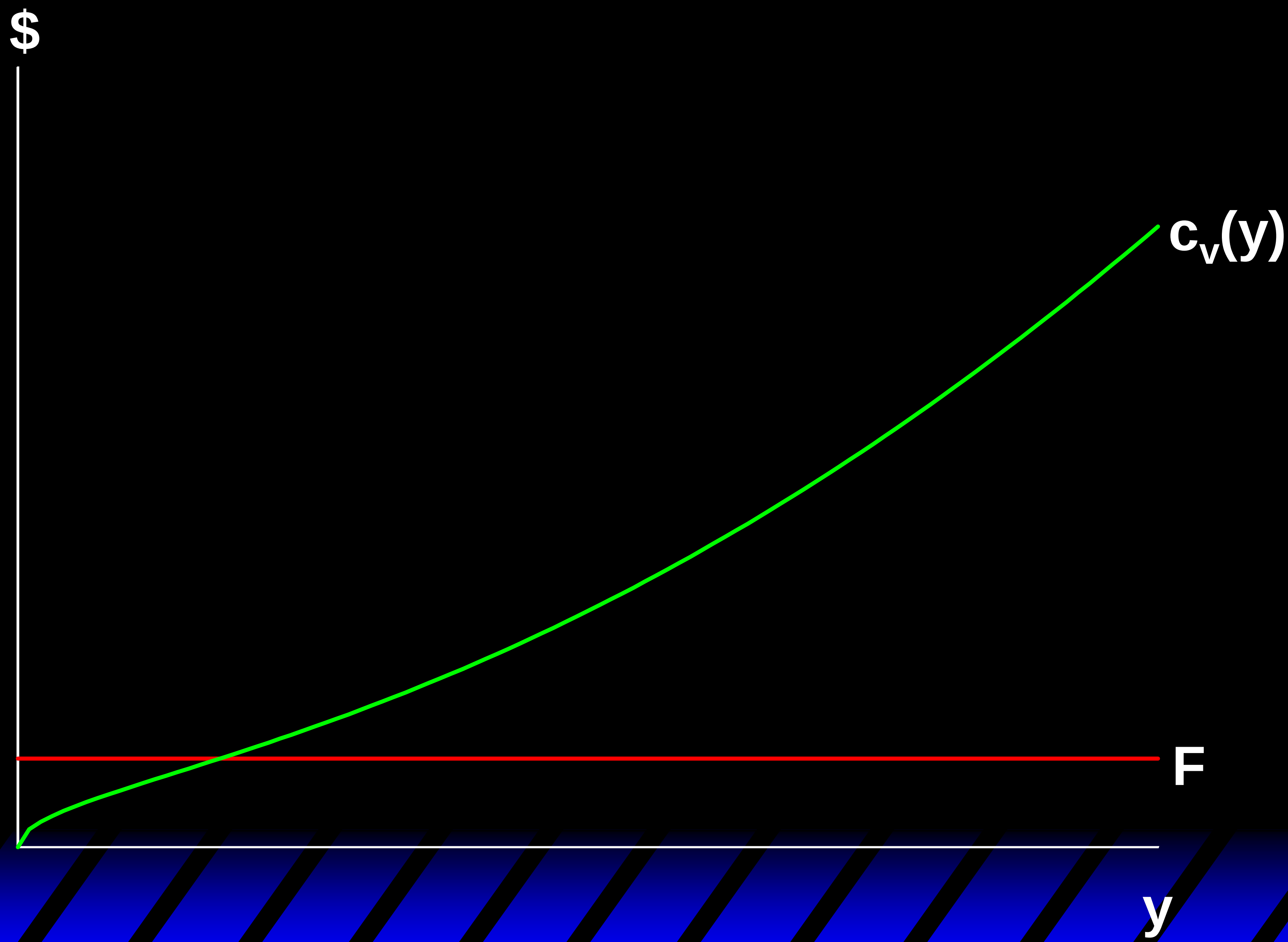
$$\mathrm{MC}(y) = \frac{\partial C(y)}{\partial y} = \frac{\partial[F + C_v(y)]}{\partial y} = \frac{\partial C_v(y)}{\partial y}$$

# Types of Cost Curves

- How are these cost curves related to each other?
- How are a firm's long-run and short-run cost curves related?


$
固定成本曲线是一条水平线
F
y

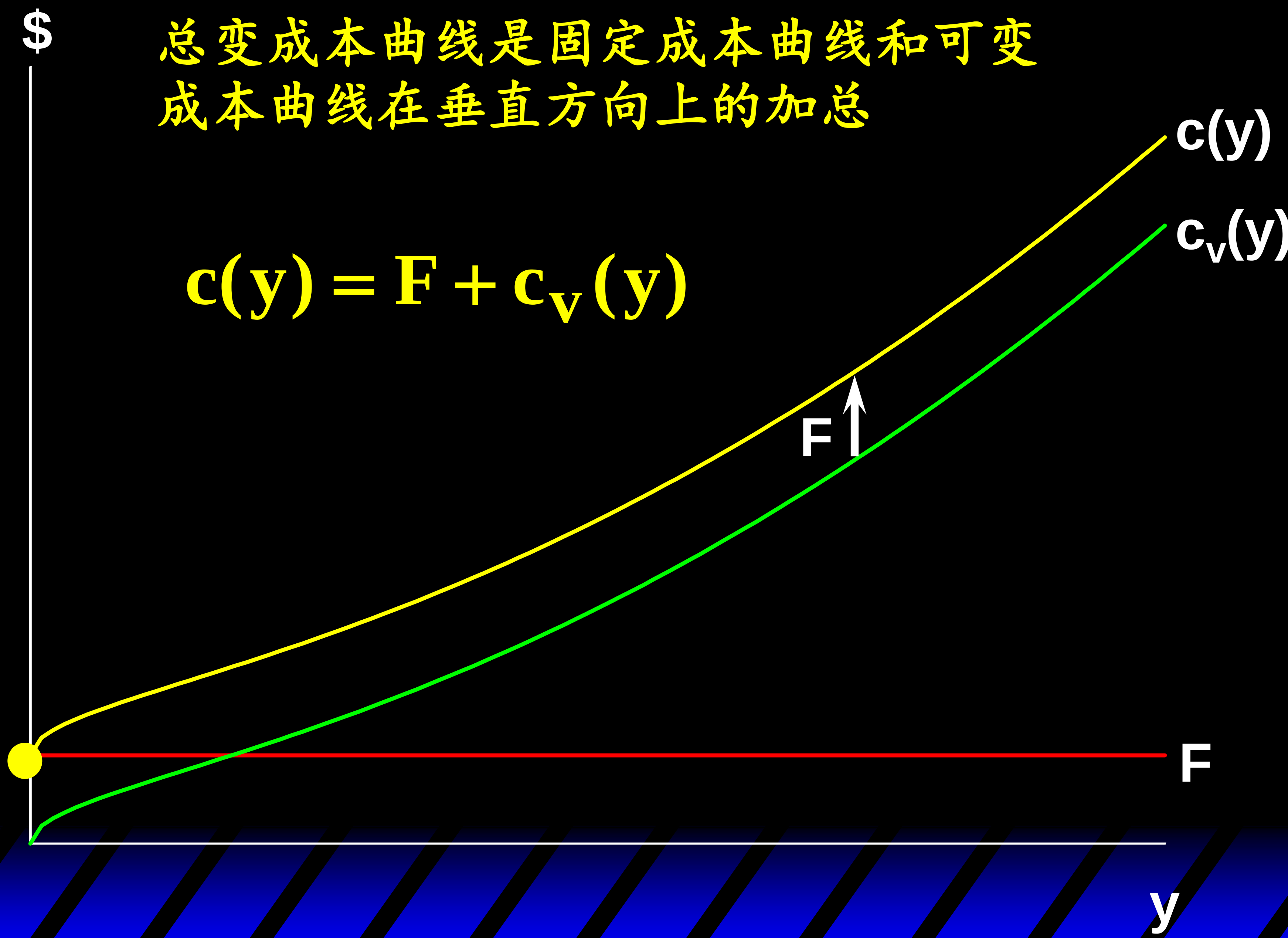

$
可变成本曲线是一条通过原点的、向上倾斜的曲线
$c_v(y)$
y



$
$c_v(y)$
F
y

总变成本曲线是固定成本曲线和可变成本曲线在垂直方向上的加总

$$c(y) = F + c_v(y)$$



# Av. Fixed, Av. Variable & Av. Total Cost Curves

The firm's total cost function is

$$c(y) = F + c_v(y).$$

For y > 0, the firm's average total cost function is

$$AC(y) = \frac{F}{y} + \frac{c_v(y)}{y}$$

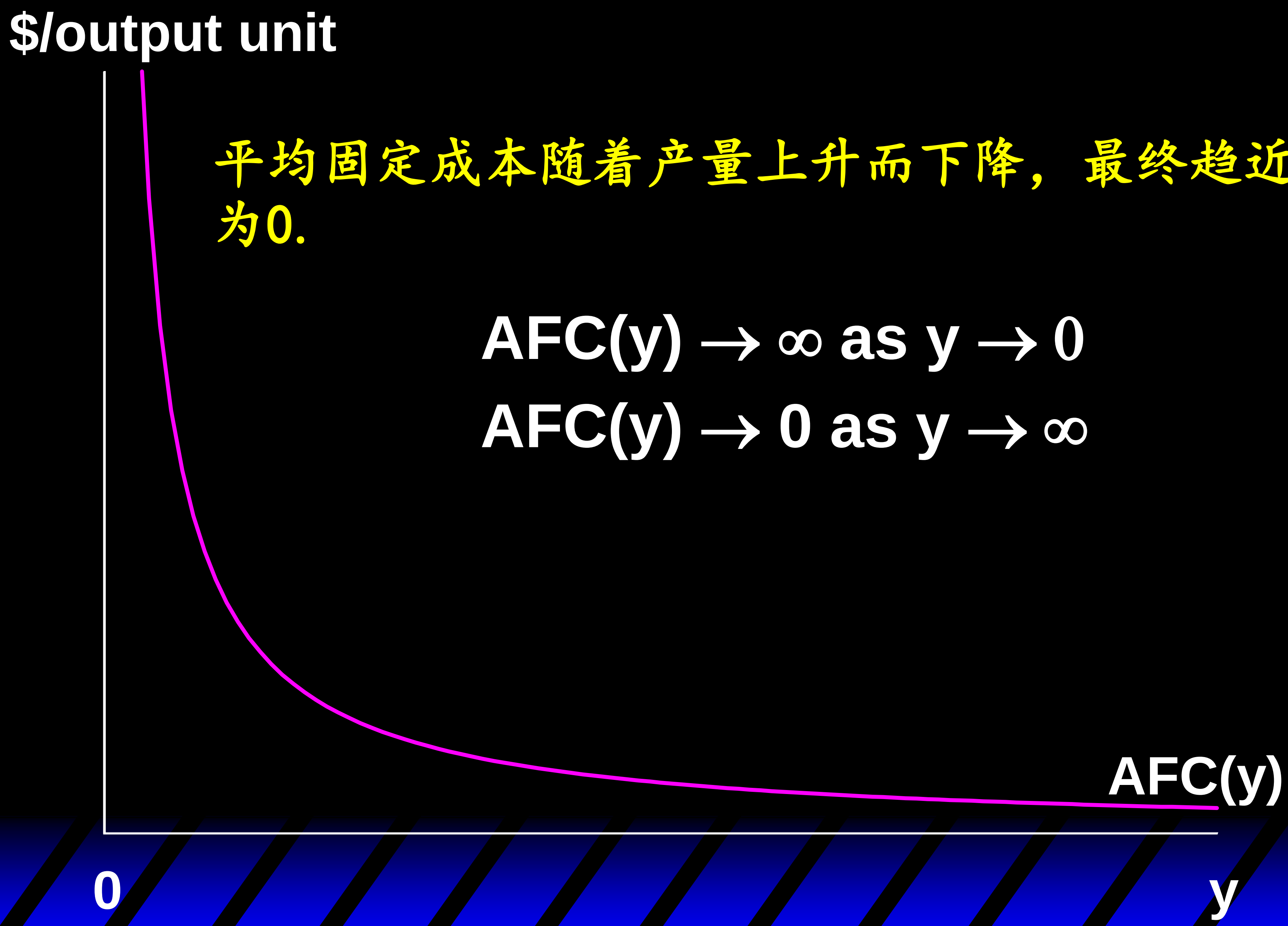
$$= AFC(y) + AVC(y).$$

# Av. Fixed, Av. Variable & Av. Total Cost Curves

**What does an average fixed cost curve look like?**

$$\mathbf{AFC(y) = \frac{F}{y}}$$

**AFC(y) is a rectangular hyperbola（双曲线）so its graph looks like ...**

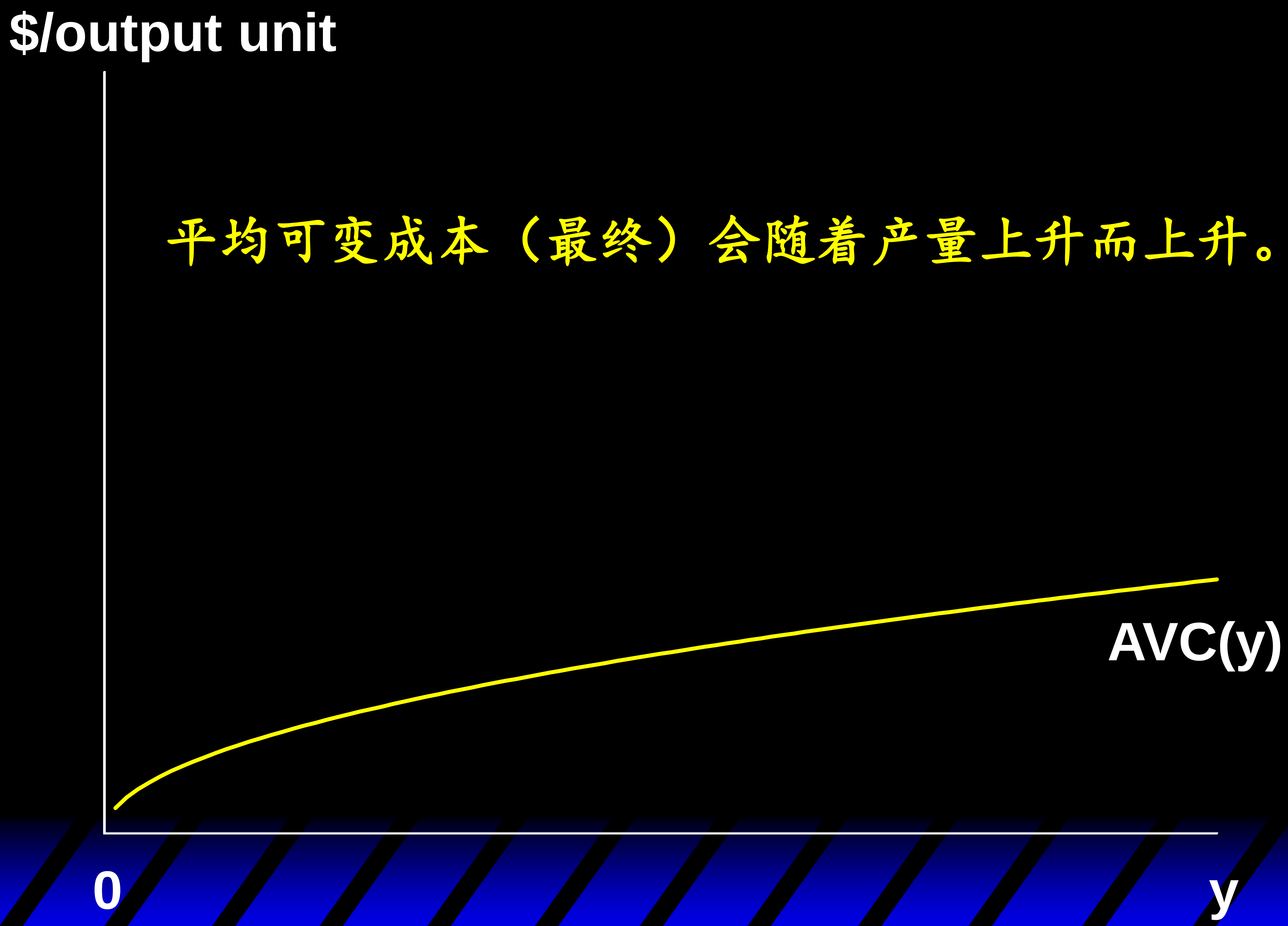


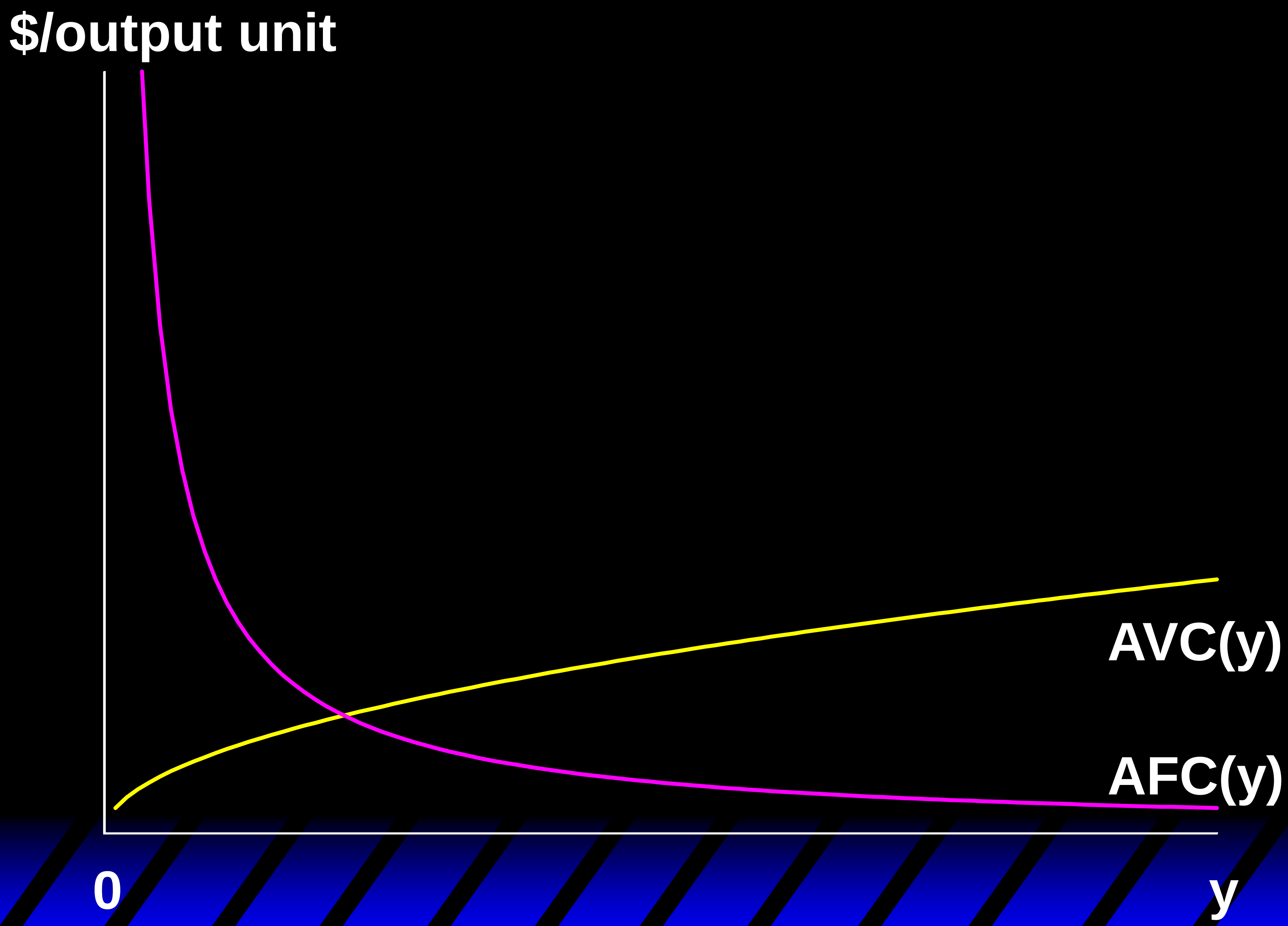
$/output unit
平均固定成本随着产量上升而下降，最终趋近为0.
AFC(y) → ∞ as y → 0
AFC(y) → 0 as y → ∞
AFC(y)
0
y

# Av. Fixed, Av. Variable & Av. Total Cost Curves

**In a short-run with a fixed amount of at least one input, the Law of Diminishing (Marginal) Returns must apply, causing the firm's average variable cost of production to increase eventually.**

当某种要素的数量固定时，生产额外一单位产品所需的其它可变要素（最终）会越来越多，因此平均可变成本（最终）会随着y上升而上升。


$/output unit
平均可变成本（最终）会随着产量上升而上升。
AVC(y)
0
y

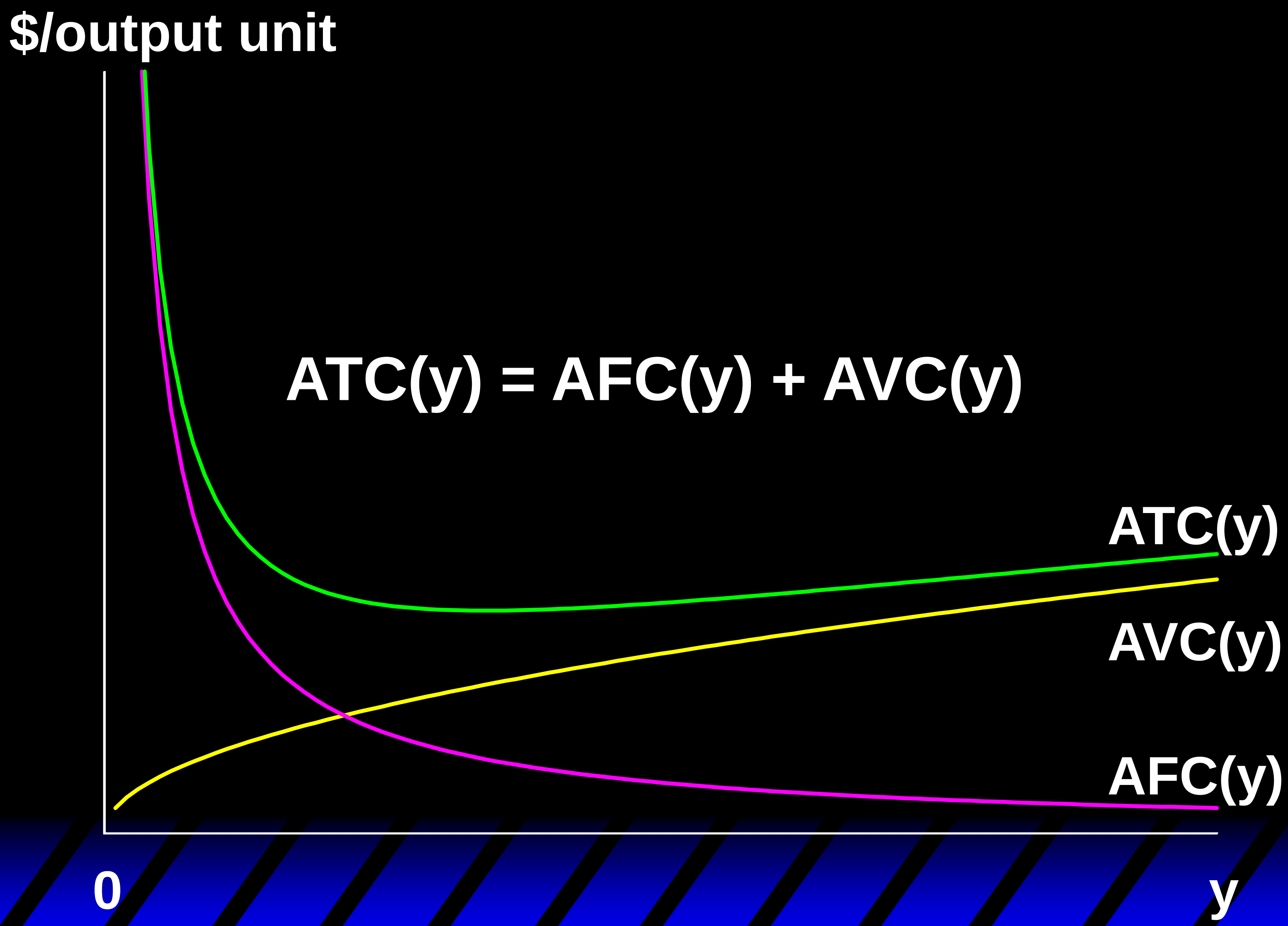

$/output unit
AVC(y)
AFC(y)
0
y

# Av. Fixed, Av. Variable & Av. Total Cost Curves

$$\mathbf{TC(y) = F + C_v(y)}$$

$$\mathbf{\frac{TC(y)}{y} = \frac{F}{y} + \frac{C_v(y)}{y}}$$

**ATC(y) = AFC(y) + AVC(y)**

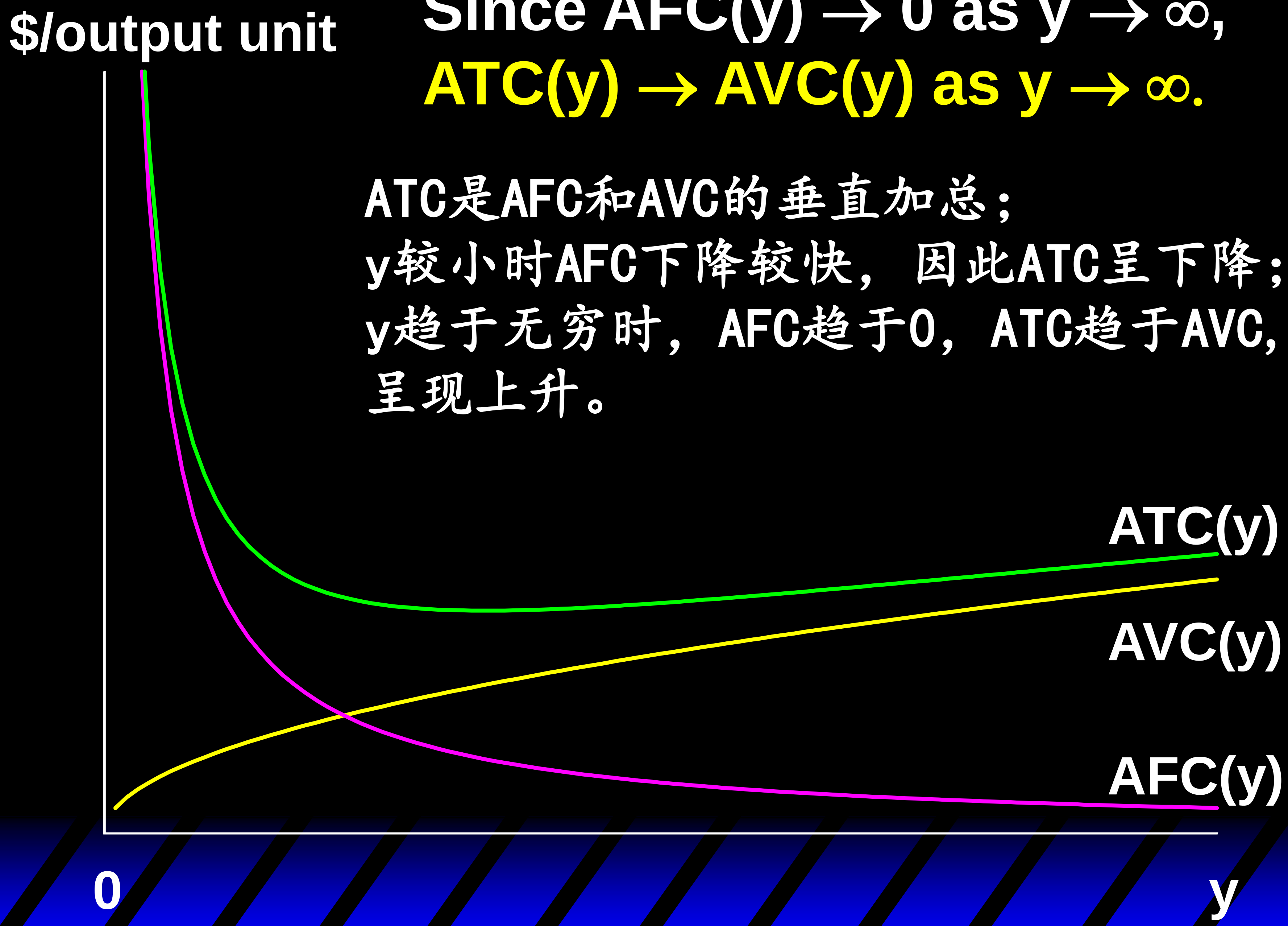



$$ATC(y) = AFC(y) + AVC(y)$$

Since AFC(y) $\rightarrow$ 0 as y $\rightarrow \infty$,

ATC(y) $\rightarrow$ AVC(y) as y $\rightarrow \infty$.

ATC是AFC和AVC的垂直加总；
y较小时AFC下降较快，因此ATC呈下降；
y趋于无穷时，AFC趋于0，ATC趋于AVC，
呈现上升。



# Marginal Cost Function

The firm's total cost function is

$$c(y) = F + c_v(y)$$

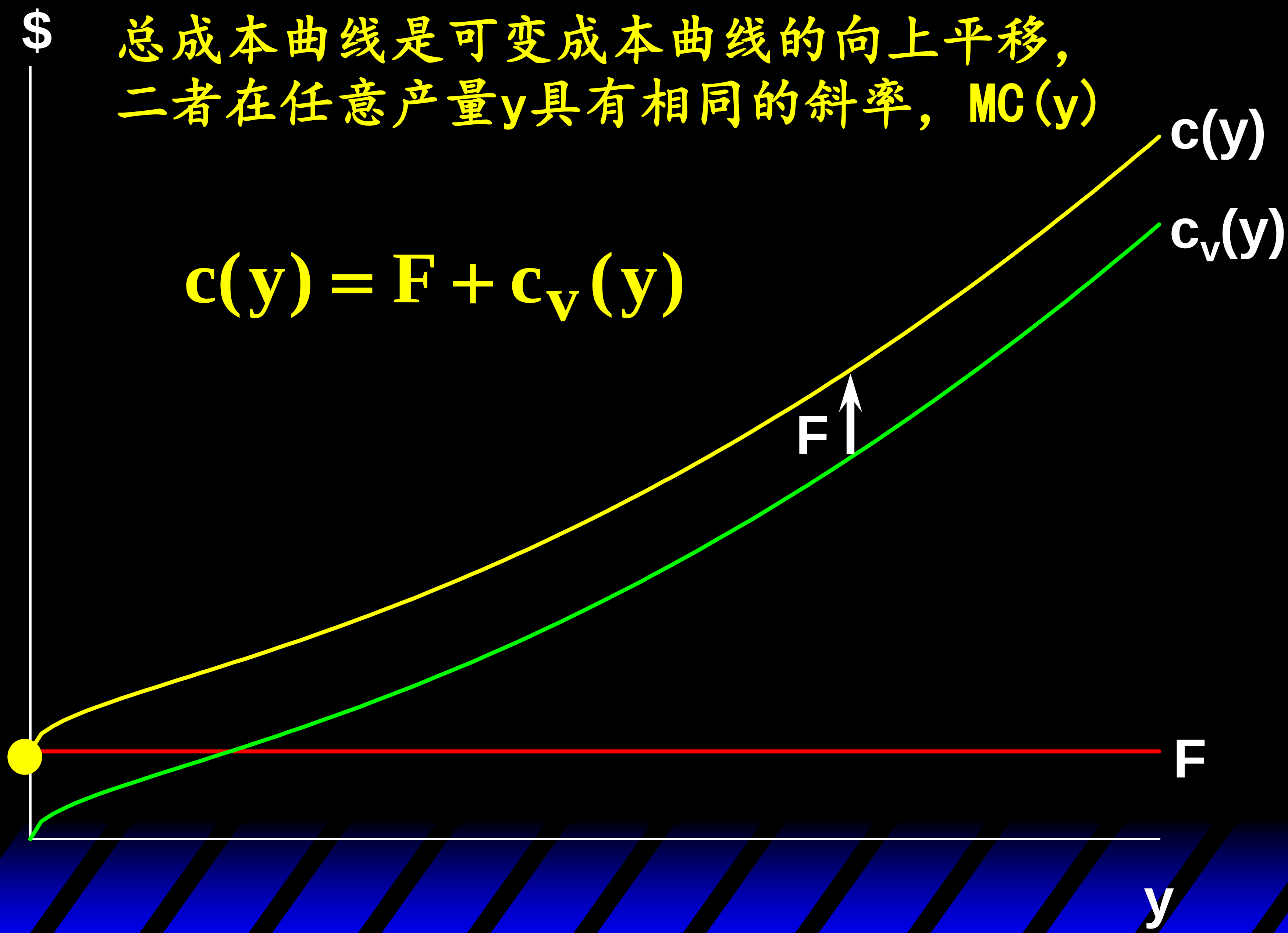
and the fixed cost F does not change with the output level y, so

$$MC(y) = \frac{\partial c_v(y)}{\partial y} = \frac{\partial c(y)}{\partial y}.$$

MC is the slope of both the variable cost and the total cost functions.

总成本曲线是可变成本曲线的向上平移，
二者在任意产量y具有相同的斜率，MC(y)

$$c(y) = F + c_v(y)$$



# Marginal and Variable Cost Functions

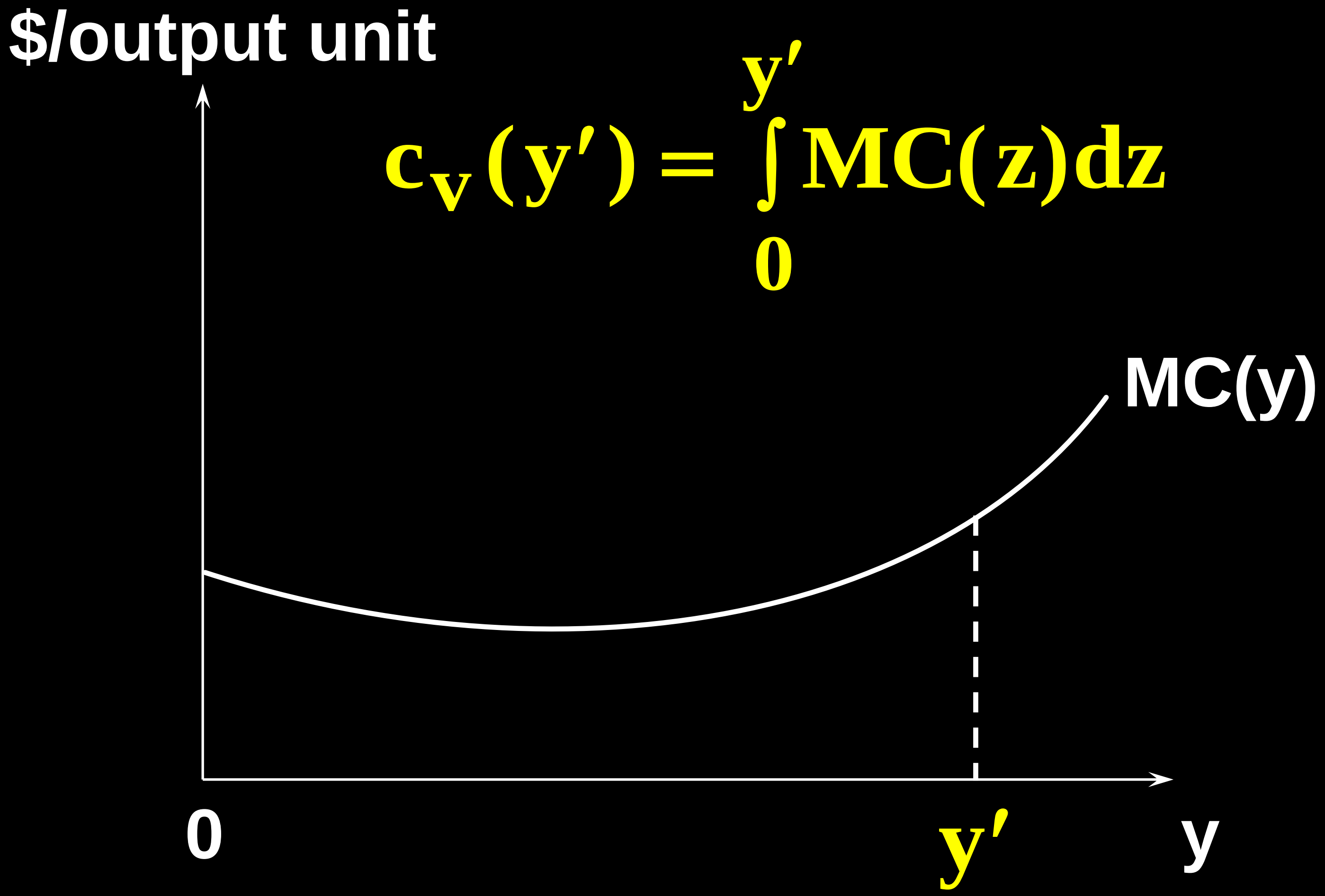
**Since MC(y) is the derivative of $c_v(y)$, $c_v(y)$ must be the integral of MC(y). That is,**

$$MC(y) = \frac{\partial c_v(y)}{\partial y}$$

$$\Rightarrow \quad c_v(y) = \int_0^y MC(z)dz.$$

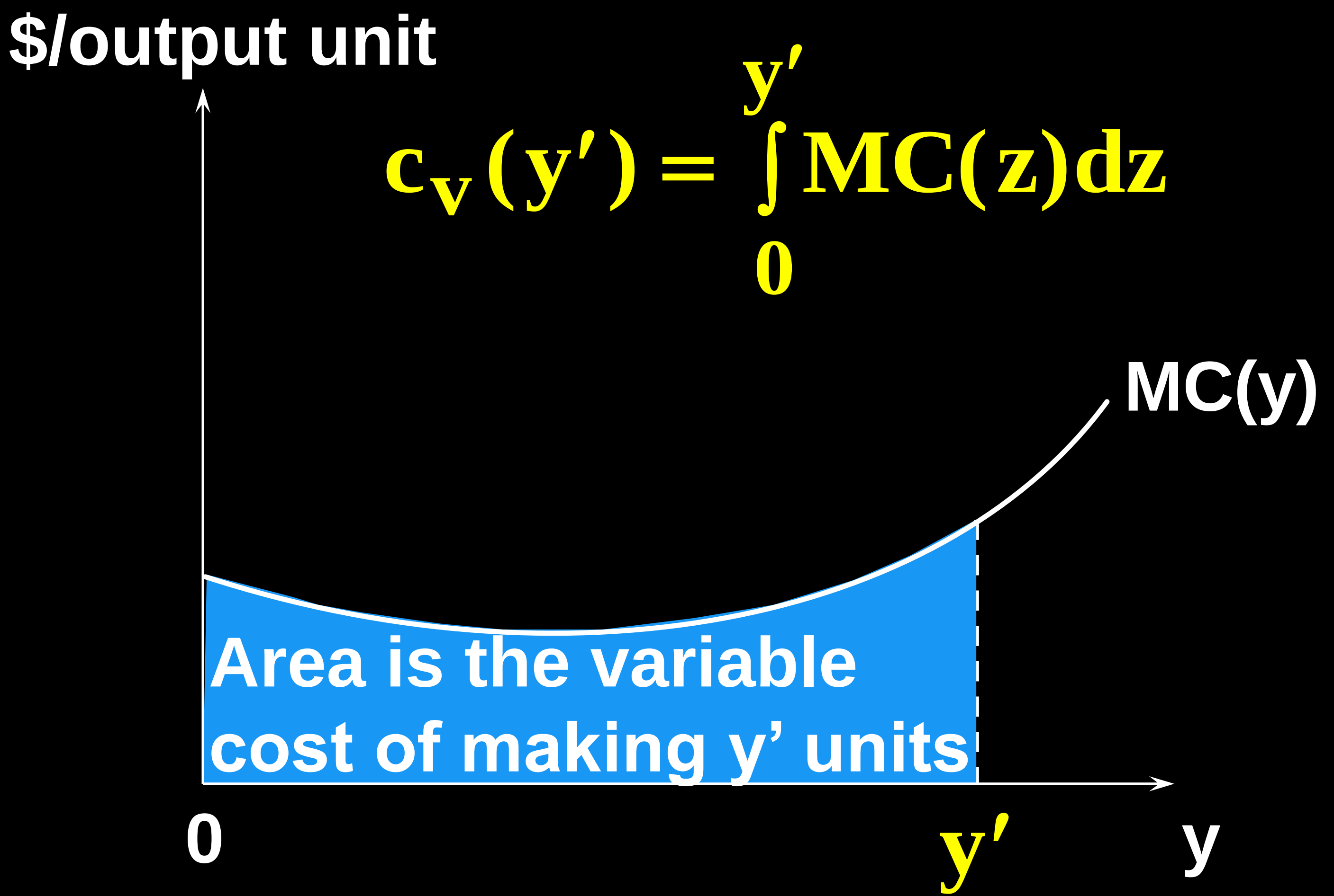
# Marginal and Variable Cost Functions

$$c_v(y') = \int_0^{y'} MC(z)\,dz$$



# Marginal and Variable Cost Functions

$$c_v(y') = \int_0^{y'} MC(z)\,dz$$



# Marginal & Average Cost Functions

**How is marginal cost related to average variable cost?**

# Marginal & Average Cost Functions

**Since** $$AVC(y) = \frac{c_v(y)}{y},$$

$$\frac{\partial\, AVC(y)}{\partial\, y} = \frac{y \times MC(y) - 1 \times c_v(y)}{y^2}.$$

# Marginal & Average Cost Functions

**Since** $$\mathbf{AVC(y) = \frac{c_v(y)}{y},}$$

$$\frac{\partial\, \mathbf{AVC(y)}}{\partial\, \mathbf{y}} = \frac{\mathbf{y \times MC(y) - 1 \times c_v(y)}}{\mathbf{y^2}}.$$

**Therefore,**

$$\frac{\partial\, \mathbf{AVC(y)}}{\partial\, \mathbf{y}} \begin{matrix} > \\ = \\ < \end{matrix} 0 \quad \text{as} \quad \mathbf{y \times MC(y)} \begin{matrix} > \\ = \\ < \end{matrix} \mathbf{c_v(y)}.$$

# Marginal & Average Cost Functions

**Since** $$AVC(y) = \frac{c_v(y)}{y},$$

$$\frac{\partial\, AVC(y)}{\partial\, y} = \frac{y \times MC(y) - 1 \times c_v(y)}{y^2}.$$

**Therefore,**

$$\frac{\partial\, AVC(y)}{\partial\, y} \begin{matrix} > \\ = \\ < \end{matrix} 0 \quad \text{as} \quad y \times MC(y) \begin{matrix} > \\ = \\ < \end{matrix} c_v(y).$$

$$\frac{\partial\, AVC(y)}{\partial\, y} \begin{matrix} > \\ = \\ < \end{matrix} 0 \quad \text{as} \quad MC(y) \begin{matrix} > \\ = \\ < \end{matrix} \frac{c_v(y)}{y} = AVC(y).$$

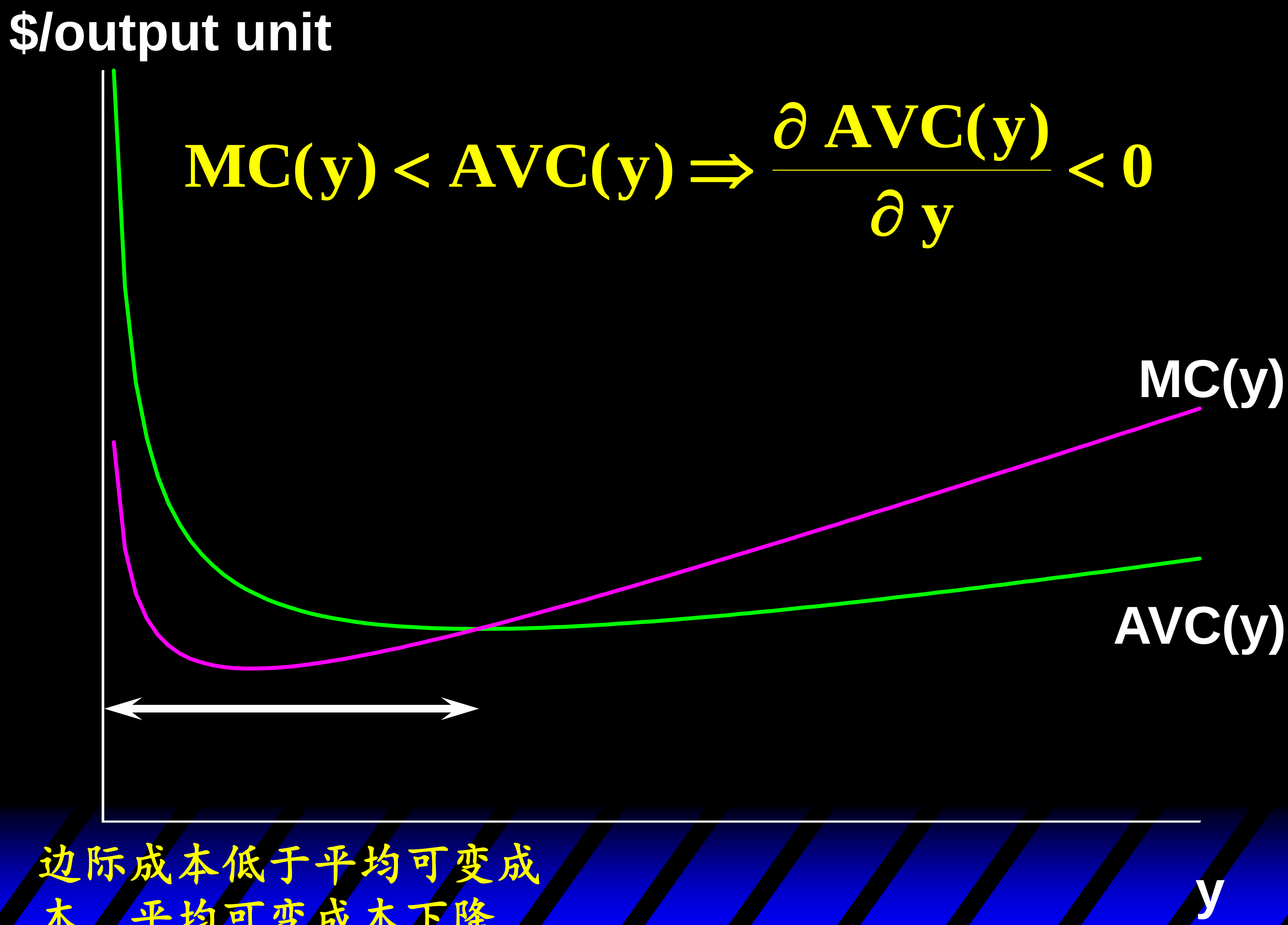
# Marginal & Average Cost Functions

$$\frac{\partial\, AVC(y)}{\partial\, y} \begin{matrix} > \\ = \\ < \end{matrix} 0 \quad \text{as} \quad MC(y) \begin{matrix} > \\ = \\ < \end{matrix} AVC(y).$$

当边际成本高于平均可变成本时，平均可变成本随产量上升而上升；

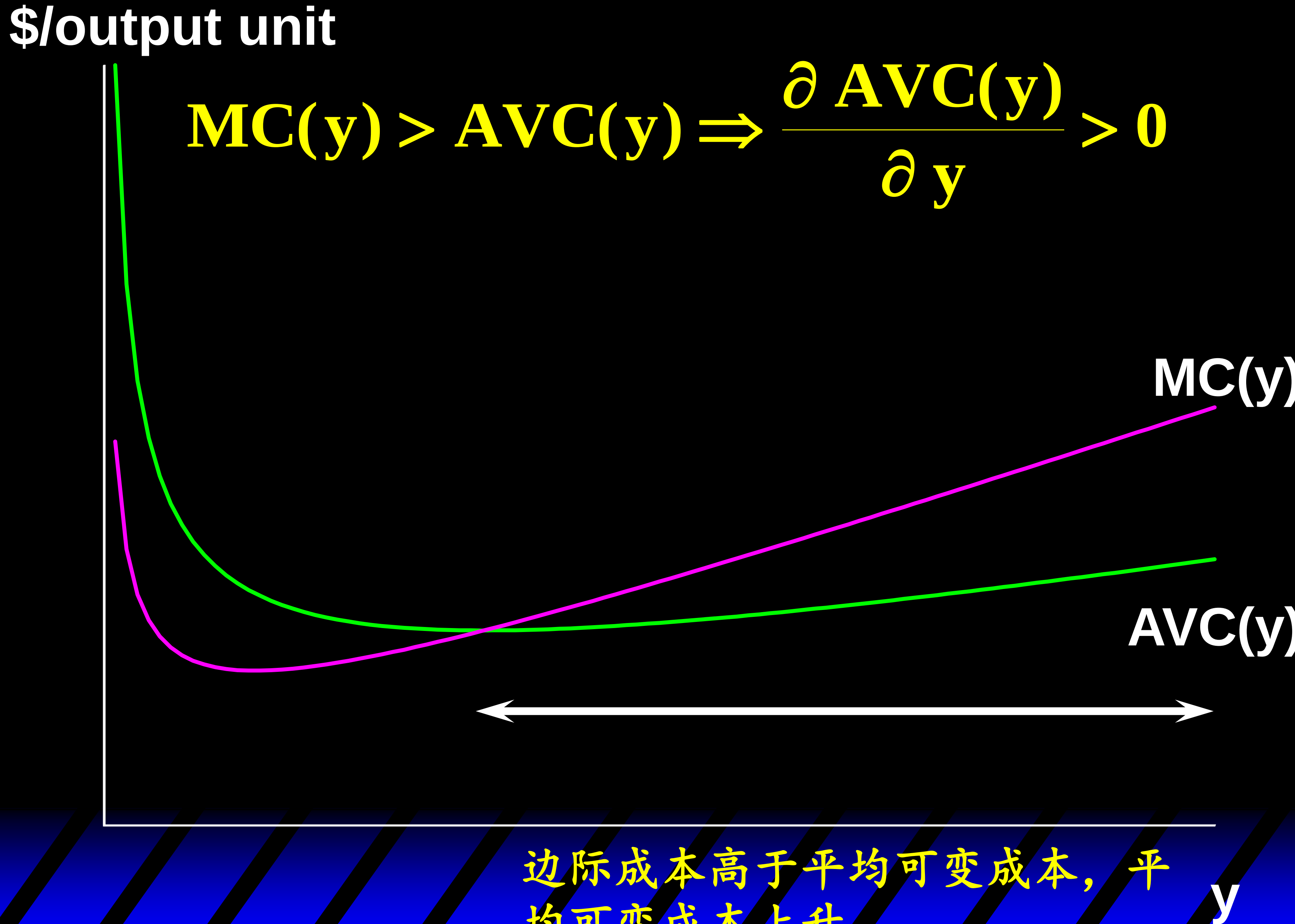
当边际成本低于平均可变成本时，平均可变成本随产量上升而下降

$$MC(y) < AVC(y) \Rightarrow \frac{\partial\, AVC(y)}{\partial\, y} < 0$$



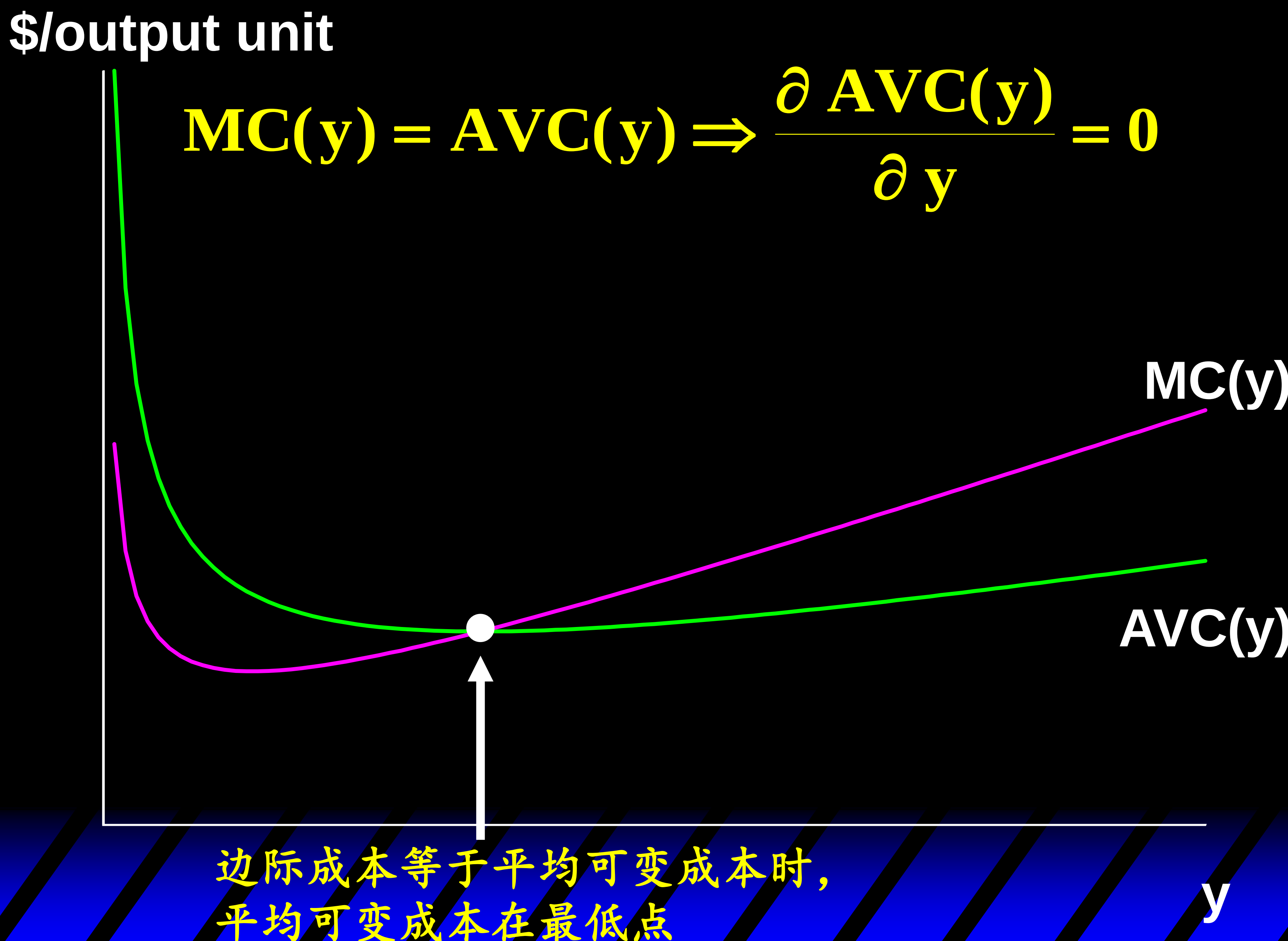

边际成本低于平均可变成本，平均可变成本下降

$$MC(y) > AVC(y) \Rightarrow \frac{\partial\, AVC(y)}{\partial\, y} > 0$$



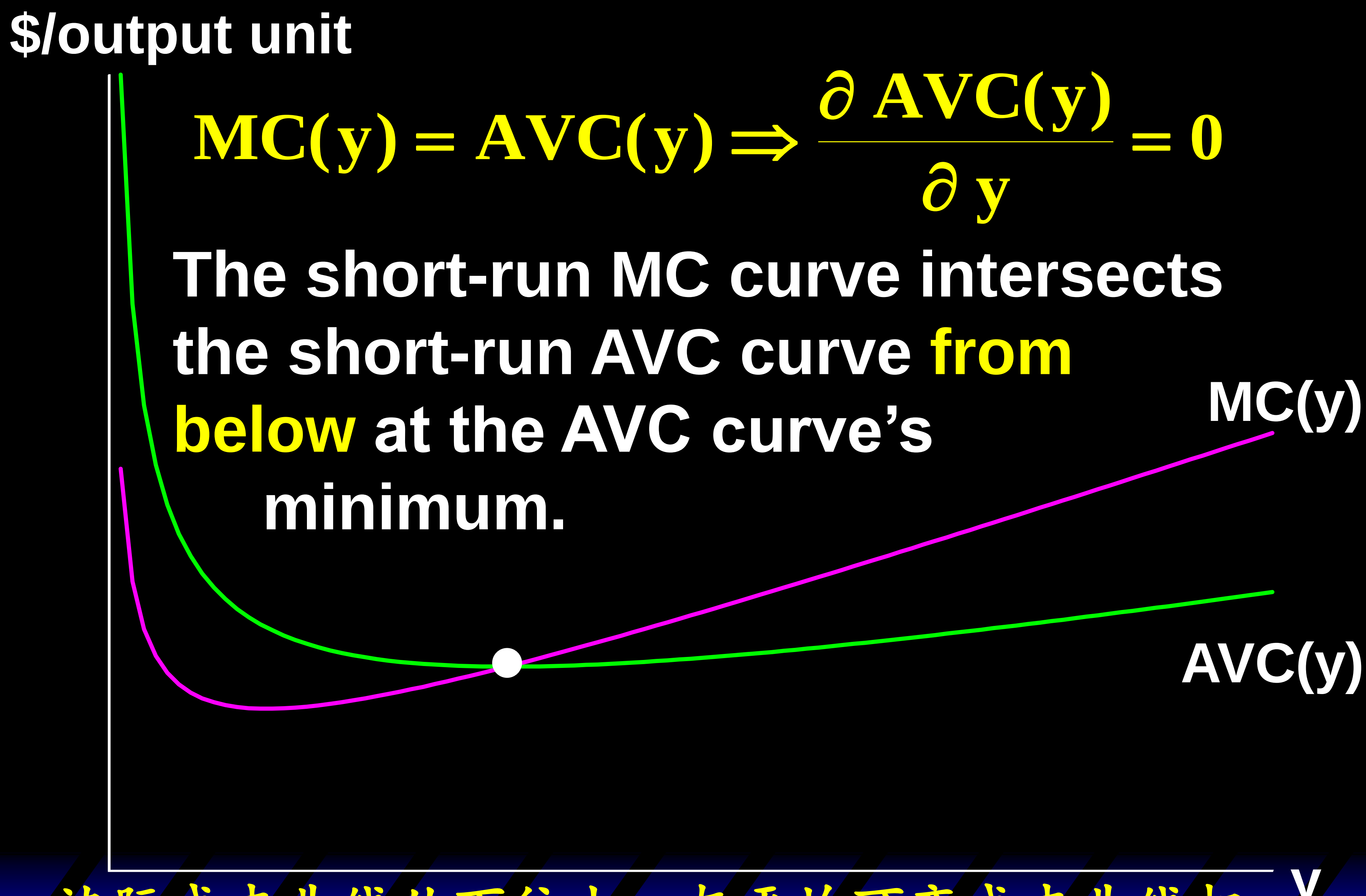

边际成本高于平均可变成本，平均可变成本上升

$$\mathbf{MC(y) = AVC(y) \Rightarrow \frac{\partial\, AVC(y)}{\partial\, y} = 0}$$



$$\mathbf{MC(y) = AVC(y) \Rightarrow \frac{\partial\, AVC(y)}{\partial\, y} = 0}$$

**The short-run MC curve intersects the short-run AVC curve from below at the AVC curve's minimum.**




边际成本曲线从下往上、与平均可变成本曲线相交于其最低点

# Marginal & Average Cost Functions

**Similarly, since** $$\mathbf{ATC(y) = \frac{c(y)}{y}},$$

$$\frac{\partial\, \mathbf{ATC(y)}}{\partial\, \mathbf{y}} = \frac{\mathbf{y \times MC(y) - 1 \times c(y)}}{\mathbf{y^2}}.$$

# Marginal & Average Cost Functions

Similarly, since $\mathbf{ATC(y) = \dfrac{c(y)}{y}}$,

$$\frac{\partial \, ATC(y)}{\partial \, y} = \frac{y \times MC(y) - 1 \times c(y)}{y^2}.$$

Therefore,

$$\frac{\partial \, ATC(y)}{\partial \, y} \begin{array}{c} > \\ = \\ < \end{array} 0 \quad \text{as} \quad y \times MC(y) \begin{array}{c} > \\ = \\ < \end{array} c(y).$$

# Marginal & Average Cost Functions

Similarly, since $\mathrm{ATC}(y) = \dfrac{c(y)}{y}$,

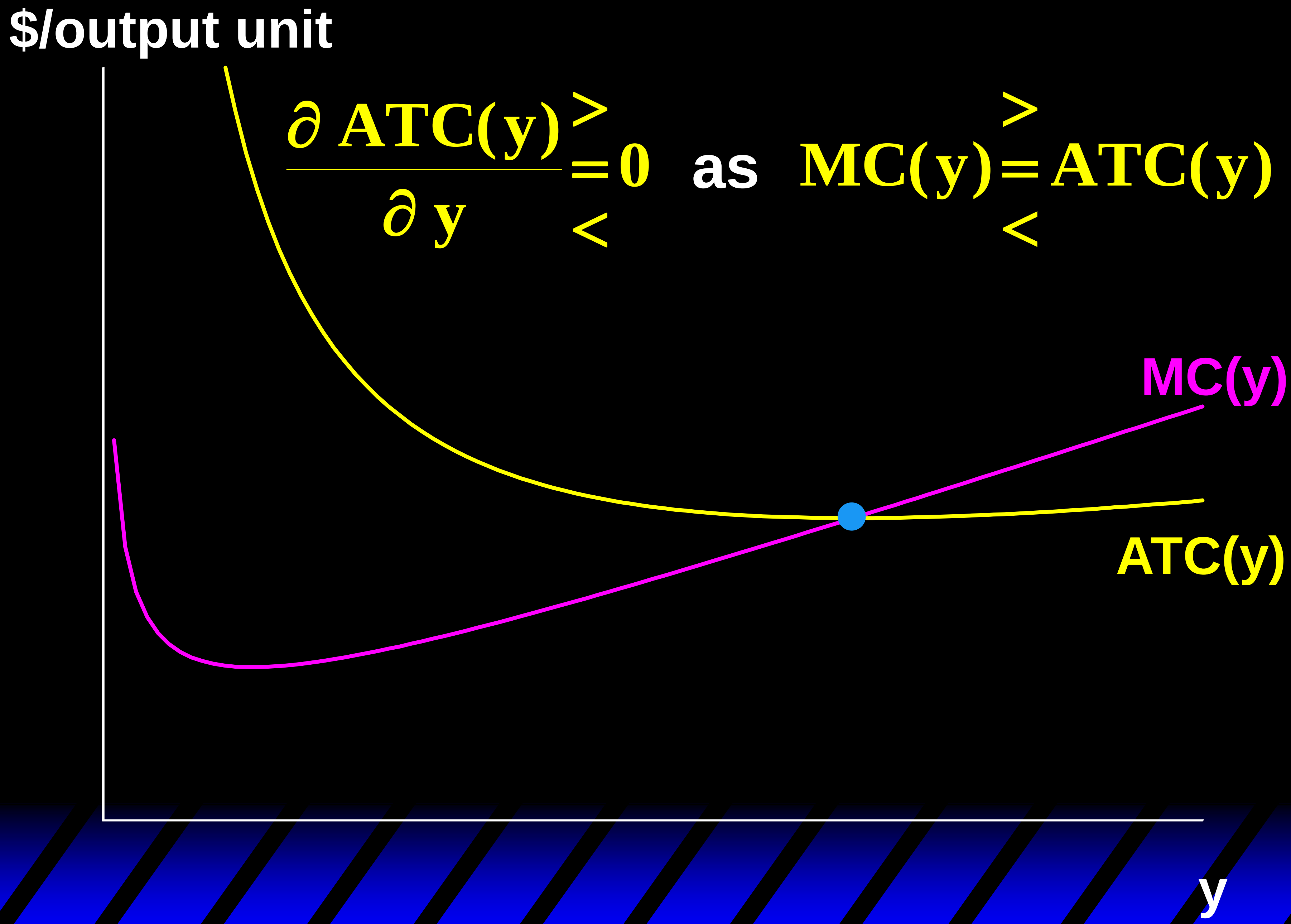
$$\frac{\partial\, \mathrm{ATC}(y)}{\partial\, y} = \frac{y \times \mathrm{MC}(y) - 1 \times c(y)}{y^2}.$$

Therefore,

$$\frac{\partial\, \mathrm{ATC}(y)}{\partial\, y} \begin{matrix} > \\ = \\ < \end{matrix} 0 \quad \text{as} \quad y \times \mathrm{MC}(y) \begin{matrix} > \\ = \\ < \end{matrix} c(y).$$

$$\frac{\partial\, \mathrm{ATC}(y)}{\partial\, y} \begin{matrix} > \\ = \\ < \end{matrix} 0 \quad \text{as} \quad \mathrm{MC}(y) \begin{matrix} > \\ = \\ < \end{matrix} \frac{c(y)}{y} = \mathrm{ATC}(y).$$

$$\frac{\partial\, ATC(y)}{\partial\, y} \;\begin{matrix} > \\ = \\ < \end{matrix}\; 0 \quad \text{as} \quad MC(y) \;\begin{matrix} > \\ = \\ < \end{matrix}\; ATC(y)$$

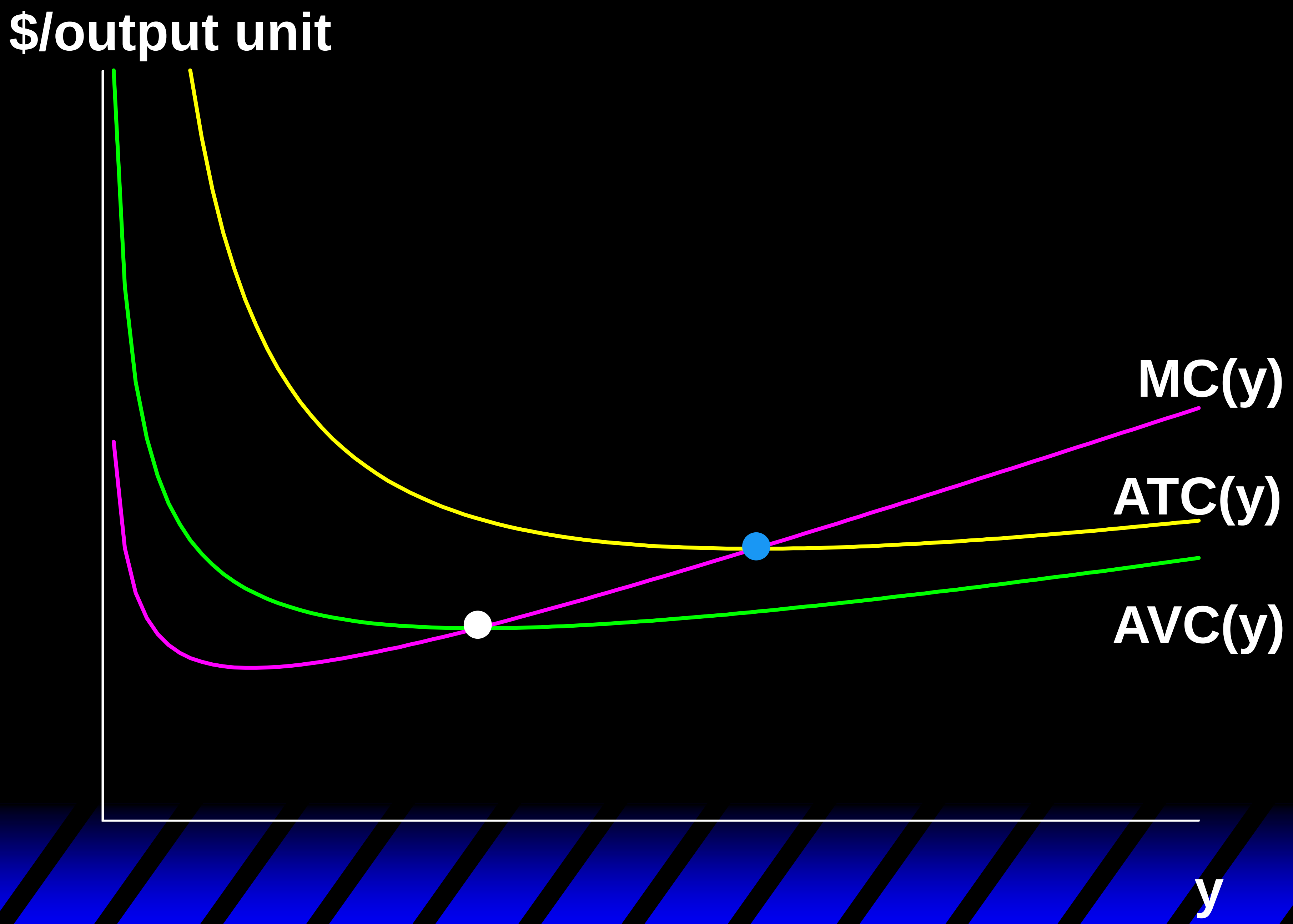


# Marginal & Average Cost Functions

**The short-run MC curve intersects the short-run AVC curve from below at the AVC curve's minimum.**

**And, similarly, the short-run MC curve intersects the short-run ATC curve from below at the ATC curve's minimum.**

边际成本曲线从下往上、与平均成本曲线相交于其最低点


$/output unit
MC(y)
ATC(y)
AVC(y)
y

# Marginal & Average Cost Functions

**Cost function:**

$$C(y) = 1 + y^2$$

$$ATC(y) = \frac{1}{y} + y$$

$$\frac{\partial ATC(y)}{\partial y} = -\frac{1}{y^2} + 1$$

**When** $\mathrm{MC(y)} = 2\mathrm{y} < \mathrm{ATC(y)} = \frac{1}{\mathrm{y}} + \mathrm{y}$**,**

$\mathrm{y} < \frac{1}{\mathrm{y}}$, $\mathrm{y} < 1$ **=>** $\frac{\partial \mathrm{ATC(y)}}{\partial \mathrm{y}} = -\frac{1}{\mathrm{y}^2} + 1 < 0$

**=> ATC遞減**

# Marginal & Average Cost Functions

**Cost function:**

$$C(y) = 1 + y^2$$

$$ATC(y) = \frac{1}{y} + y$$

$$\frac{\partial ATC(y)}{\partial y} = -\frac{1}{y^2} + 1$$

**When** $\mathbf{MC(y) = 2y > ATC(y) = \frac{1}{y} + y,}$

$\mathbf{y > \frac{1}{y}, y > 1}$ **=>** $\mathbf{\frac{\partial ATC(y)}{\partial y} = -\frac{1}{y^2} + 1 > 0}$

**=> ATC遞增**

# Marginal & Average Cost Functions

**Cost function:**

$$C(y) = 1 + y^2$$

$$ATC(y) = \frac{1}{y} + y$$

$$\frac{\partial ATC(y)}{\partial y} = -\frac{1}{y^2} + 1$$

**When** $\mathrm{MC(y)} = 2\mathrm{y} = \mathrm{ATC(y)} = \frac{1}{\mathrm{y}} + \mathrm{y},$

$\mathrm{y} = 1$ => $\frac{\partial \mathrm{ATC(y)}}{\partial \mathrm{y}} = -\frac{1}{\mathrm{y}^2} + 1 = 0$ => **ATC 最小**

# Short-Run & Long-Run Total Cost Curves

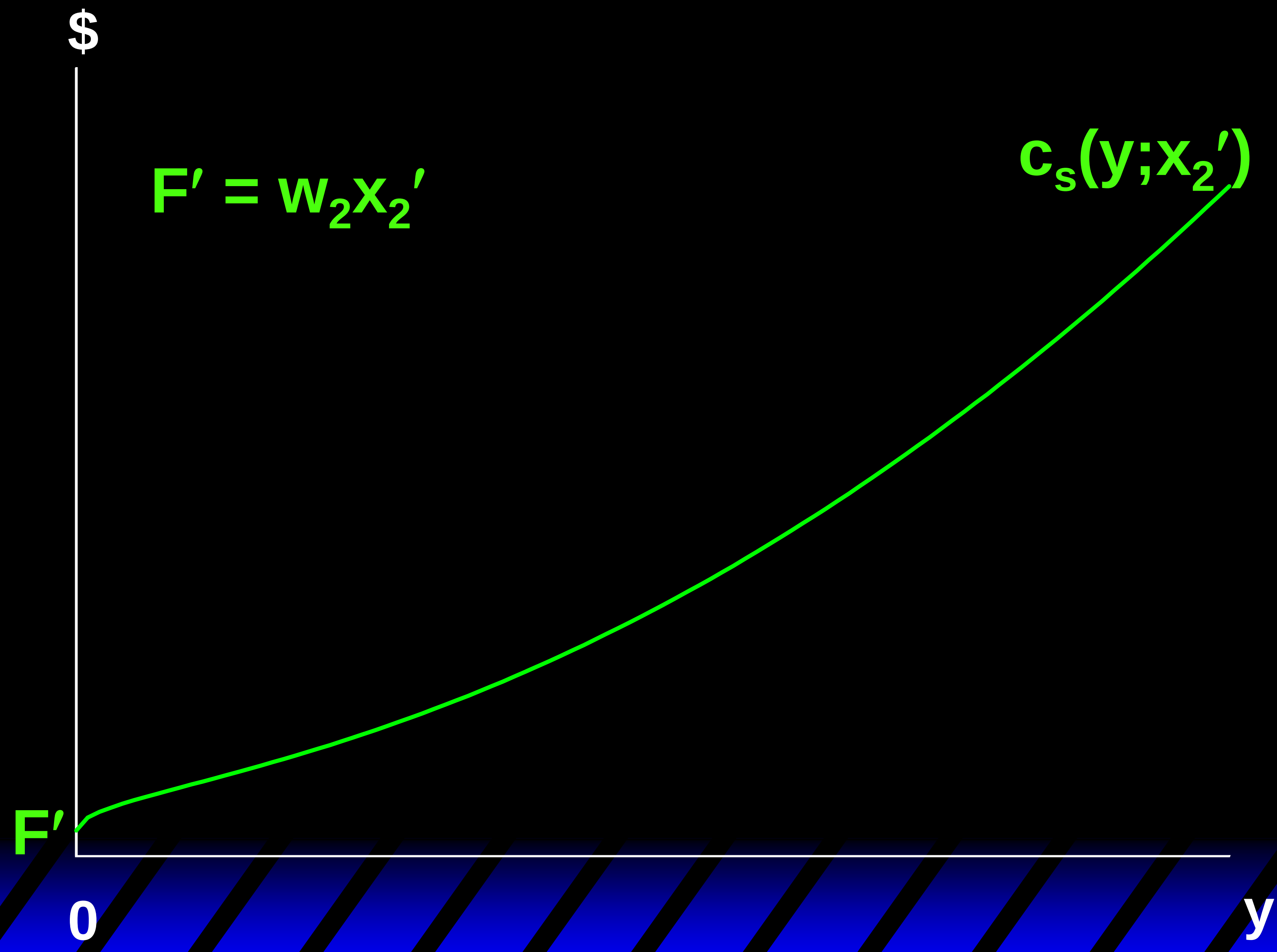
A firm has a different short-run total cost curve for each possible short-run circumstance.

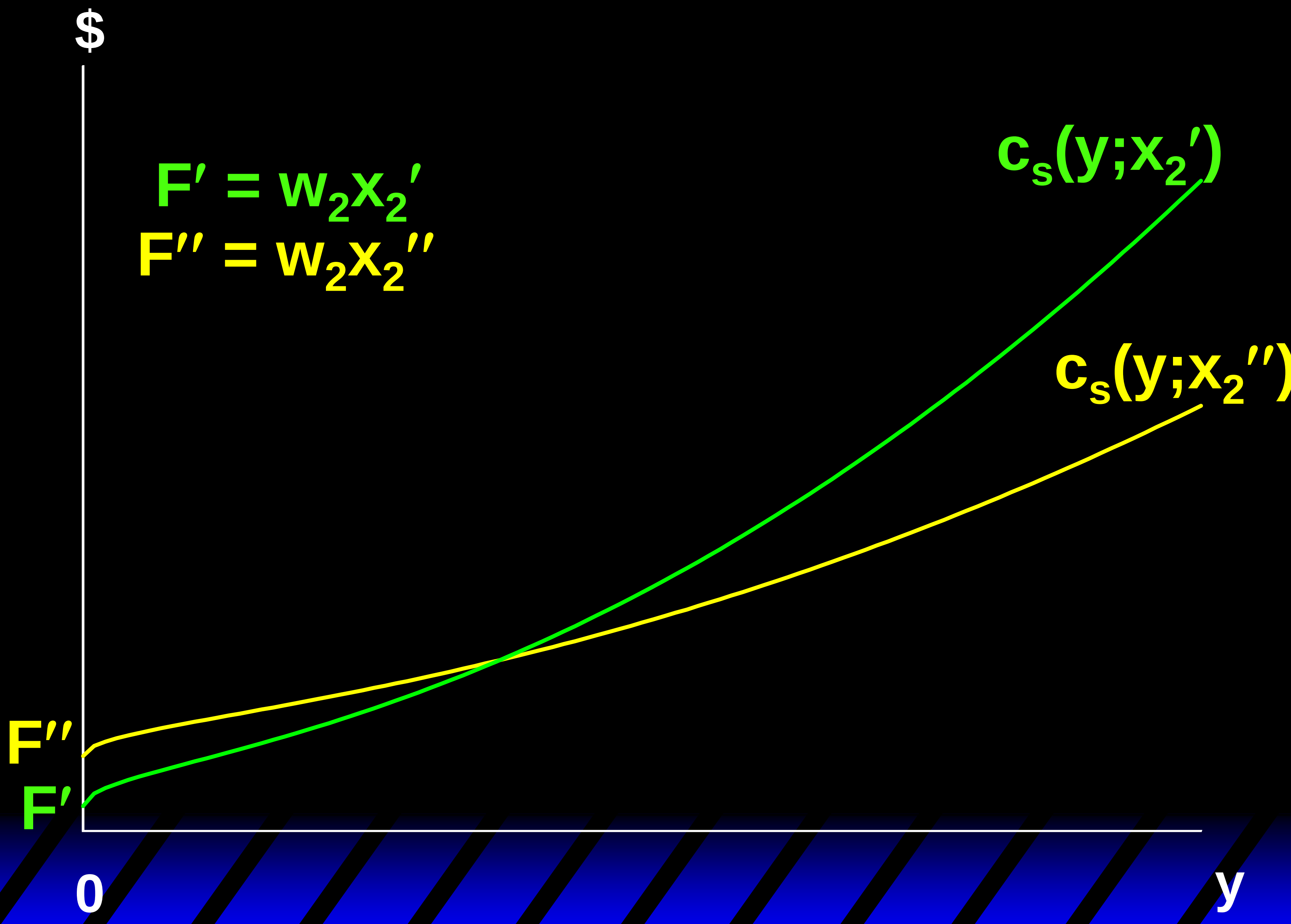
Suppose the firm can be in one of just three short-runs;

$x_2 = x_2'$

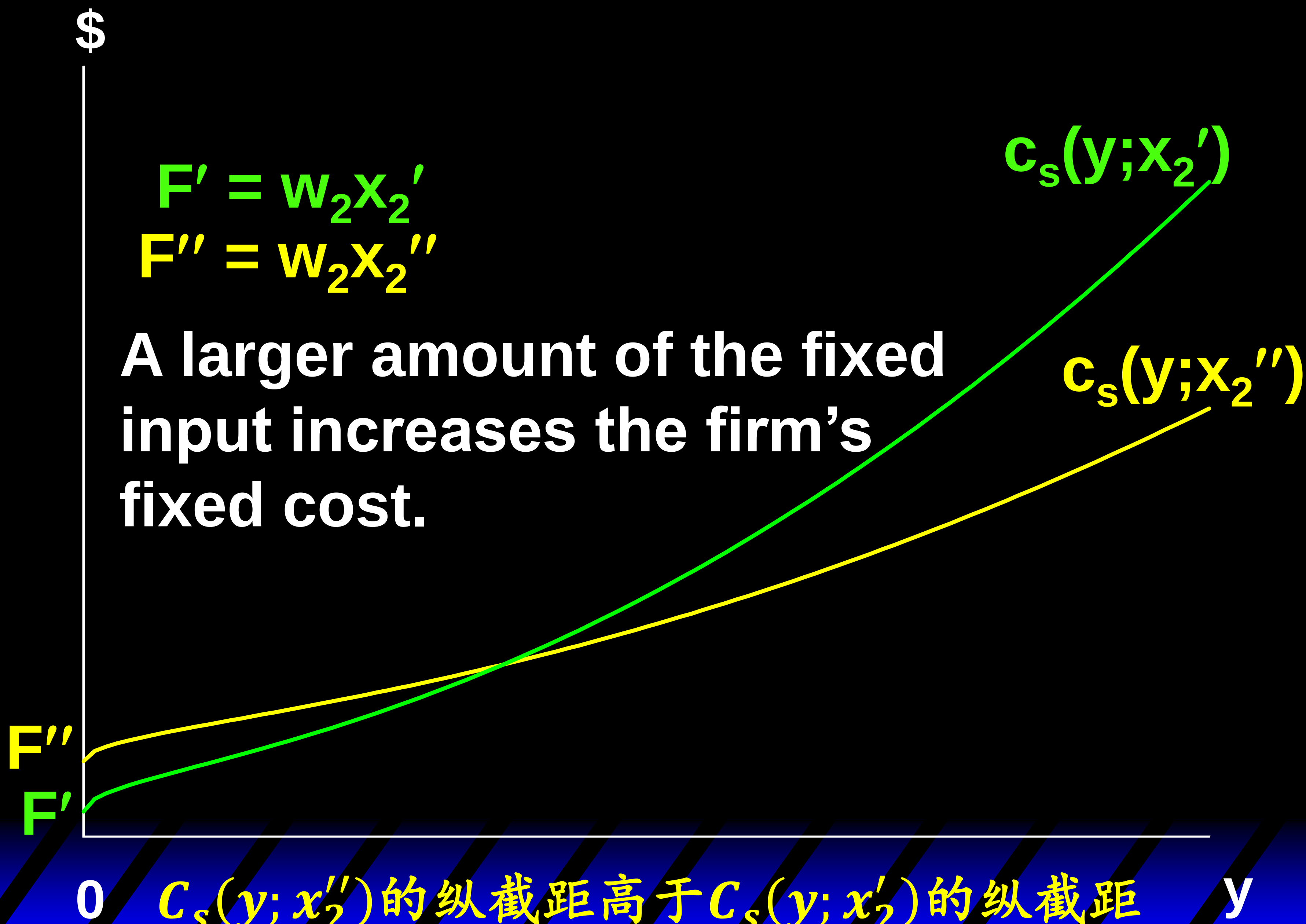
or $x_2 = x_2''$ $x_2' < x_2'' < x_2'''$.

or $x_2 = x_2'''$.


$
F′ = w₂x₂′
cs(y;x₂′)
F′
0
y

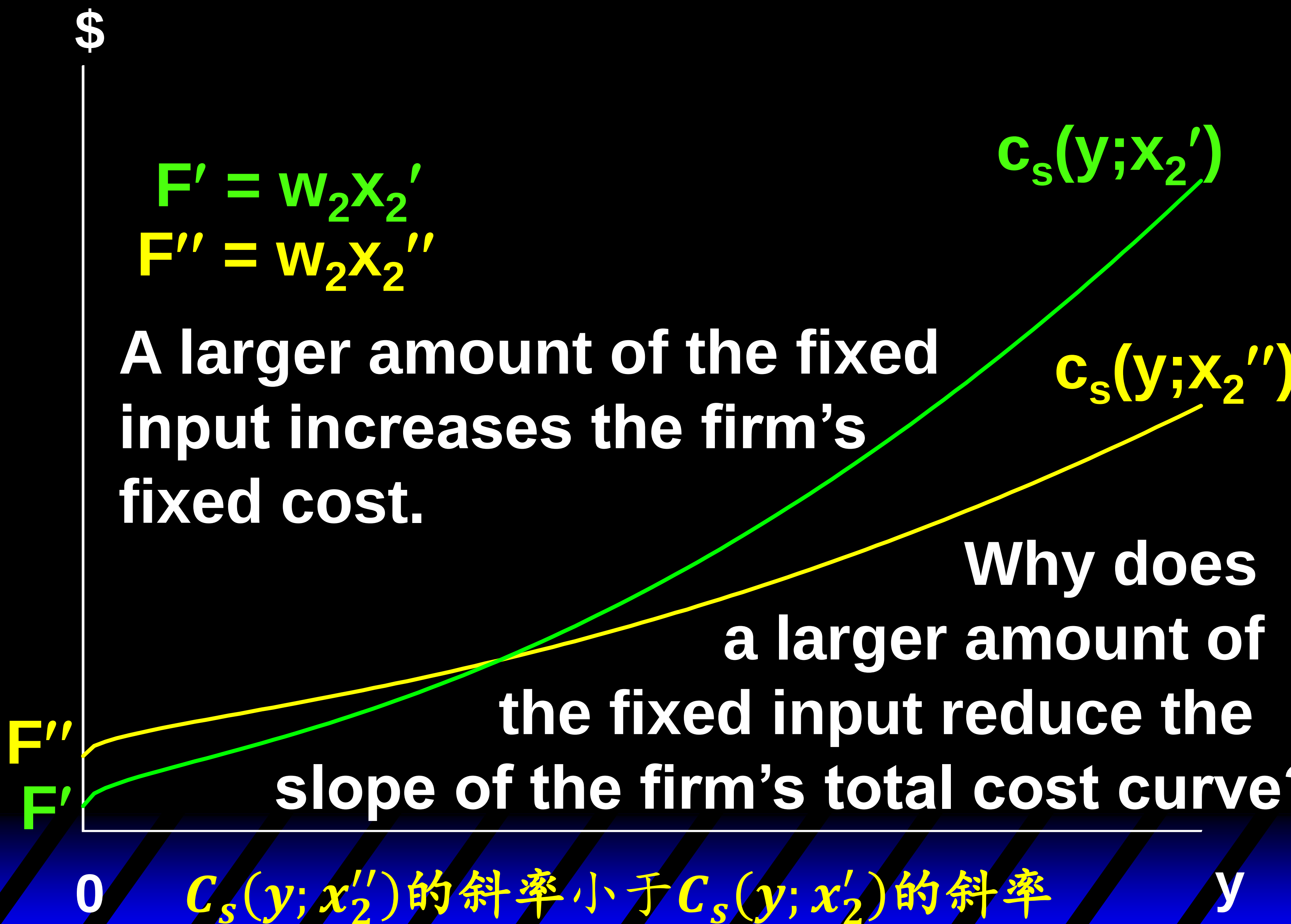


$
F′ = w2x2′
F″ = w2x2″
cs(y;x2′)
cs(y;x2″)
F″
F′
0
y




A larger amount of the fixed input increases the firm's fixed cost.

$C_s(y;x_2'')$的纵截距高于$C_s(y;x_2')$的纵截距




$F' = w_2x_2'$

$F'' = w_2x_2''$

A larger amount of the fixed input increases the firm's fixed cost.

Why does a larger amount of the fixed input reduce the slope of the firm's total cost curve?

$C_s(y;x_2'')$的斜率小于$C_s(y;x_2')$的斜率

# Short-Run & Long-Run Total Cost Curves

**$MP_1$ is the marginal physical productivity of the variable input 1, so one extra unit of input 1 gives $MP_1$ extra output units. Therefore, the extra amount of input 1 needed for 1 extra output unit is**

**$1/MP_1$ units of input 1.**

$c_s(y;x_2'')$的斜率是边际成本，即额外1单位产出的花费；

额外1单位要素1能生产$MP_1$，即额外1单位产出需要$1/MP_1$单位要素1，那么边际成本$=\omega_1/MP_1$

# Short-Run & Long-Run Total Cost Curves

$MP_1$ is the marginal physical productivity of the variable input 1, so one extra unit of input 1 gives $MP_1$ extra output units. Therefore, the extra amount of input 1 needed for 1 extra output unit is

$1/MP_1$ units of input 1.

Each unit of input 1 costs $w_1$, so the firm's extra cost from producing one extra unit of output is $MC = \dfrac{w_1}{MP_1}.$

# Short-Run & Long-Run Total Cost Curves

$$\mathrm{MC} = \frac{\mathrm{w}_1}{\mathrm{MP}_1}$$ is the slope of the firm's total cost curve.

$MP_1 = \frac{\partial f(x_1, x_2)}{\partial x_1}$随$x_2$增加而增加

即：$MP_1(\mathrm{x}_1, \mathrm{x}_2'') > MP_1(\mathrm{x}_1, \mathrm{x}_2')$

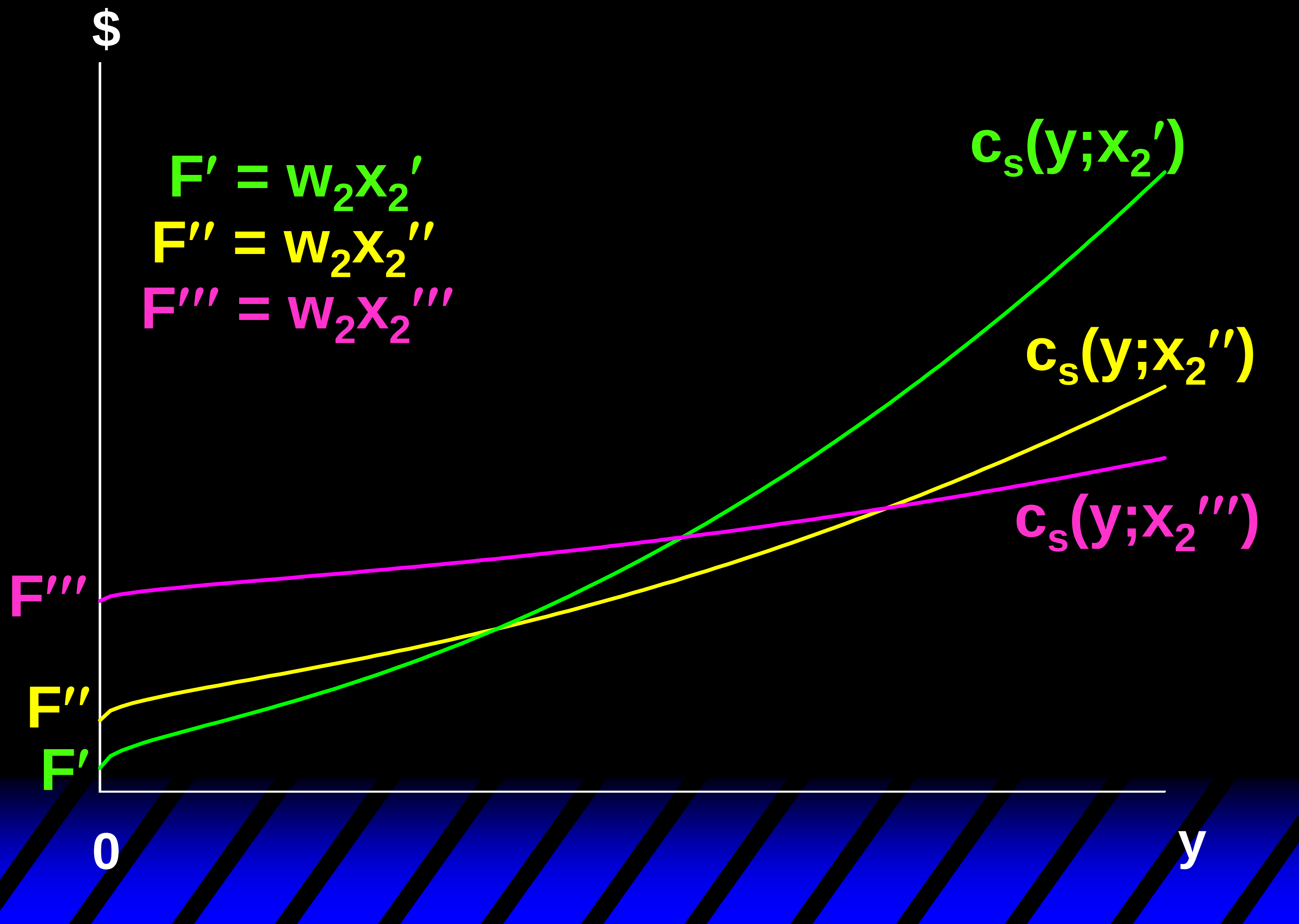
$MC(\mathrm{x}_1, \mathrm{x}_2'') < MC_1(\mathrm{x}_1, \mathrm{x}_2')$

# Short-Run & Long-Run Total Cost Curves

$$MC = \frac{w_1}{MP_1}$$ is the slope of the firm's total cost curve.

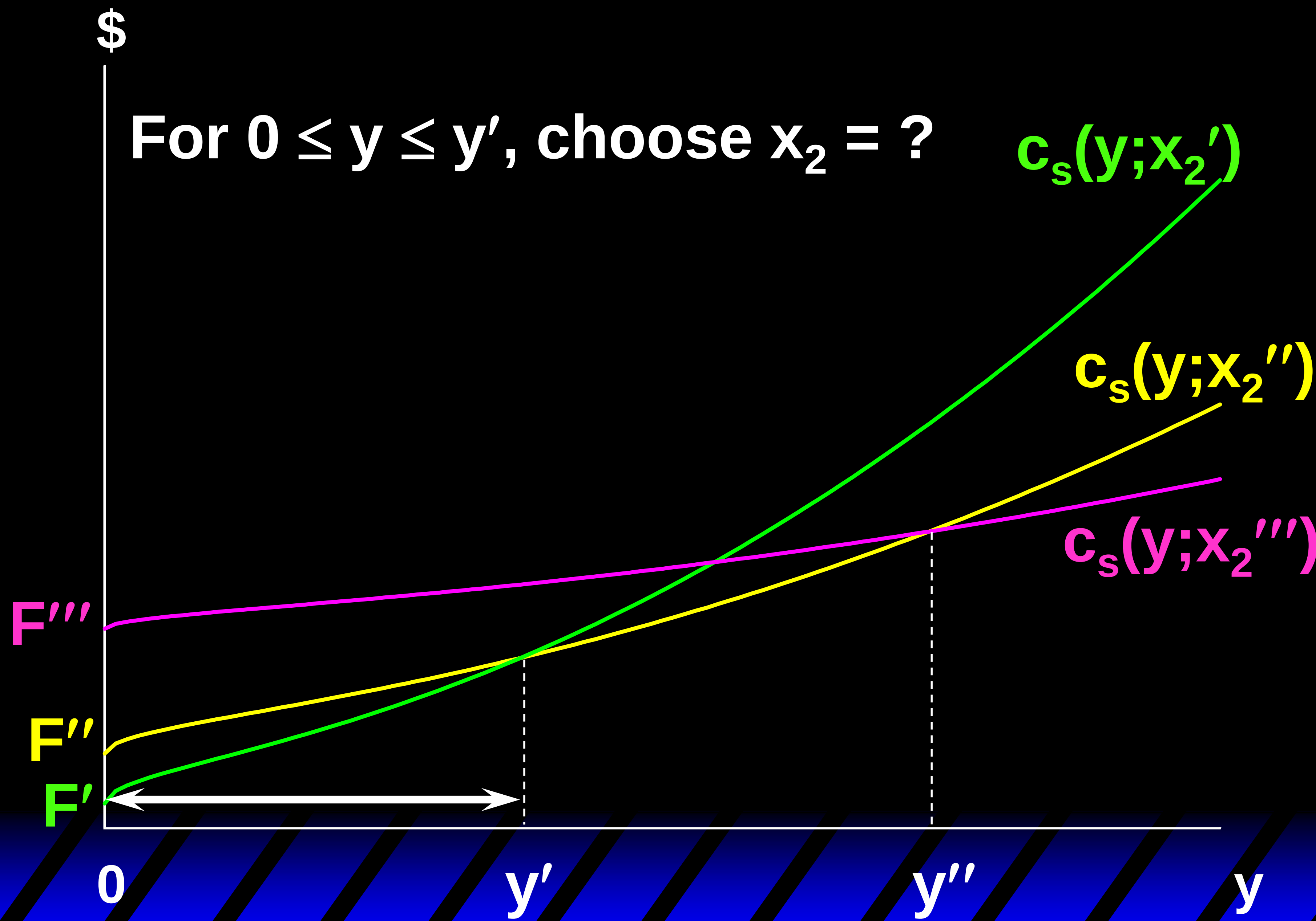
That is, a short-run total cost curve starts higher and has a lower slope if $x_2$ is larger.

不变要素的固定数量越大，对应的短期成本曲线纵截距越高、斜率越小

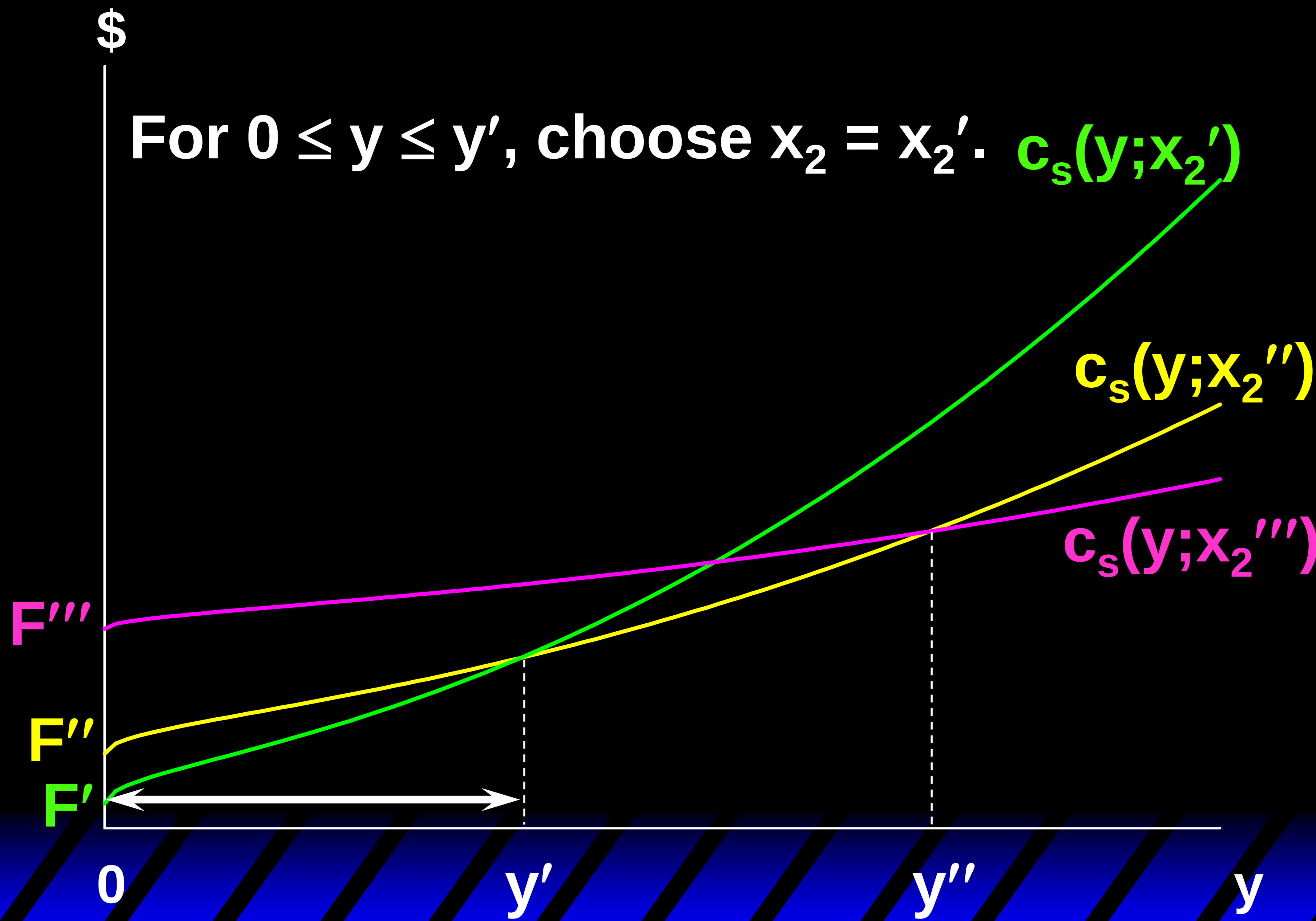

$
$F' = w_2x_2'$
$F'' = w_2x_2''$
$F''' = w_2x_2'''$
$c_s(y;x_2')$
$c_s(y;x_2'')$
$c_s(y;x_2''')$
$F'''$
$F''$
$F'$
0
y

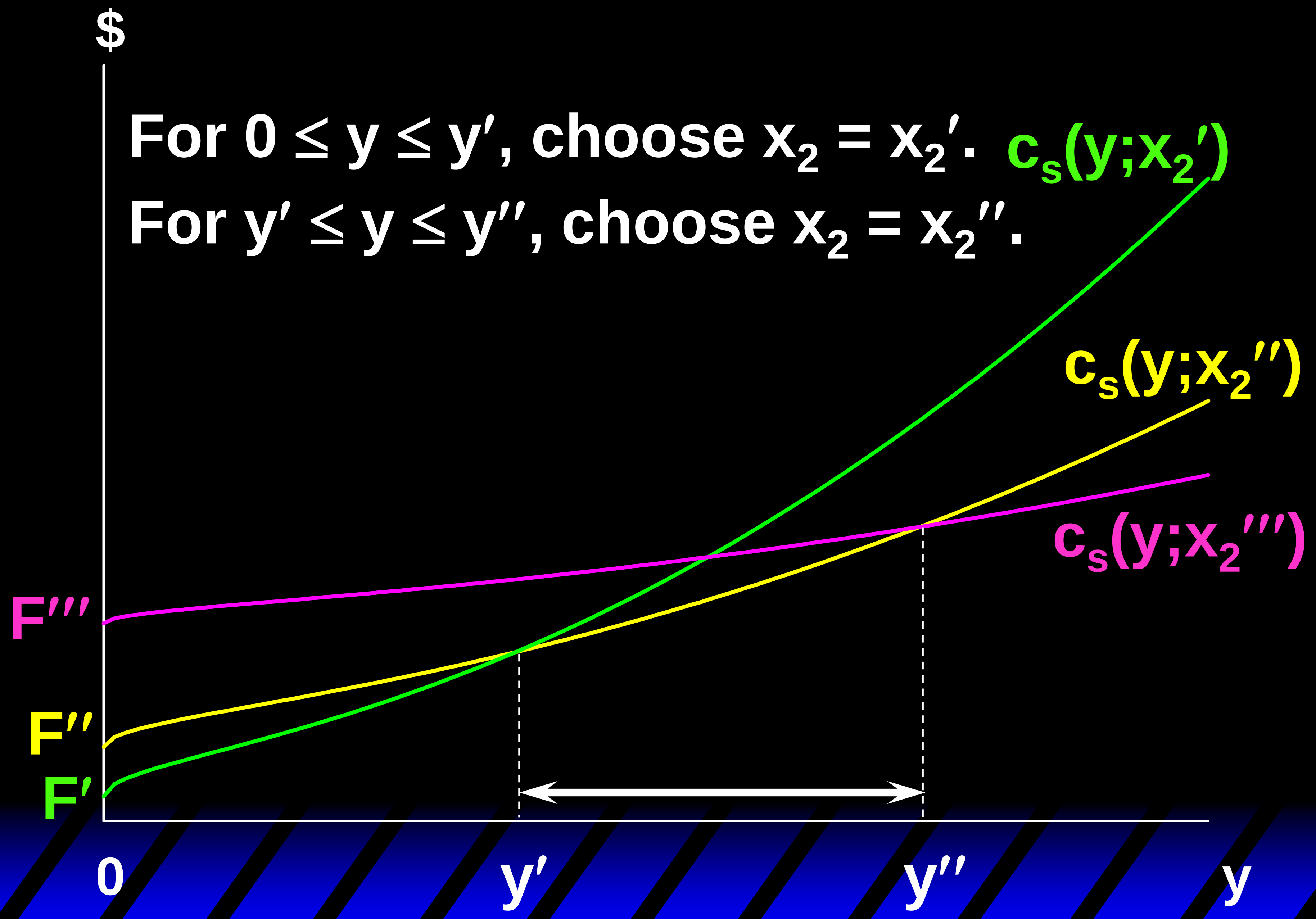
# Short-Run & Long-Run Total Cost Curves

- The firm has **three** short-run total cost curves.
- In the long-run the firm is free to choose amongst these three since it is free to select $x_2$ equal to any of $x_2'$, $x_2''$, or $x_2'''$.
- How does the firm make this choice?



$
For $0 \le y \le y'$, choose $x_2$ = ?
$c_s(y;x_2')$
$c_s(y;x_2'')$
$c_s(y;x_2''')$
F‴
F″
F′
0
y′
y″
y

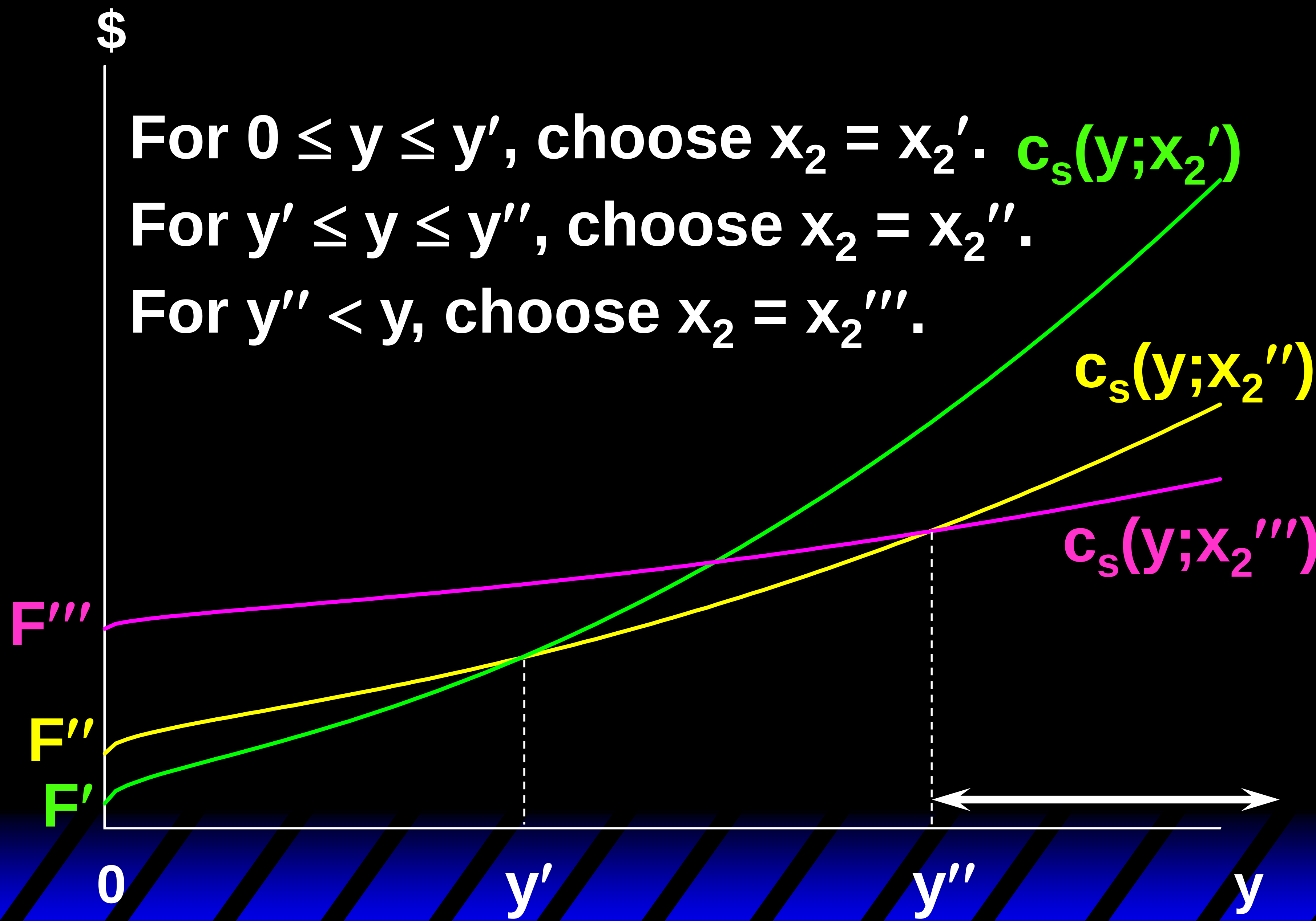

$
For $0 \leq y \leq y'$, choose $x_2 = x_2'$.
$c_s(y;x_2')$
$c_s(y;x_2'')$
$c_s(y;x_2''')$
$F'''$
$F''$
$F'$
0
$y'$
$y''$
y

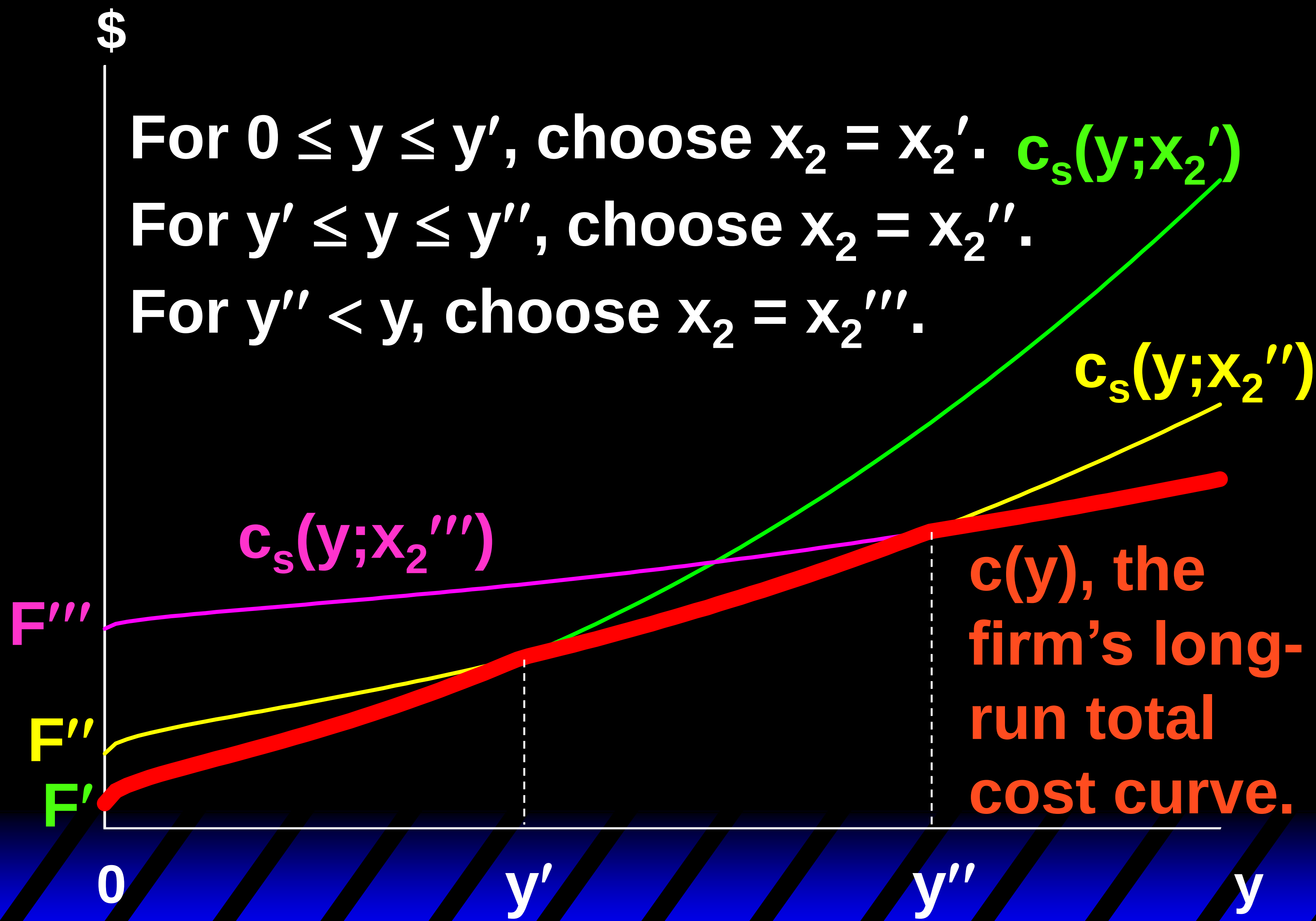

$
For 0 ≤ y ≤ y′, choose x2 = x2′.
For y′ ≤ y ≤ y″, choose x2 = x2″.
cs(y;x2′)
cs(y;x2″)
cs(y;x2‴)
F‴
F″
F′
0
y′
y″
y

For $0 \leq y \leq y'$, choose $x_2 = x_2'$.

For $y' \leq y \leq y''$, choose $x_2 = x_2''$.

For $y'' < y$, choose $x_2 = x_2'''$.




$
For 0 ≤ y ≤ y′, choose x₂ = x₂′.
For y′ ≤ y ≤ y″, choose x₂ = x₂″.
For y″ < y, choose x₂ = x₂‴.
c_s(y;x₂′)
c_s(y;x₂″)
c_s(y;x₂‴)
c(y), the firm’s long-run total cost curve.
F‴
F″
F′
0
y′
y″
y

# Short-Run & Long-Run Total Cost Curves

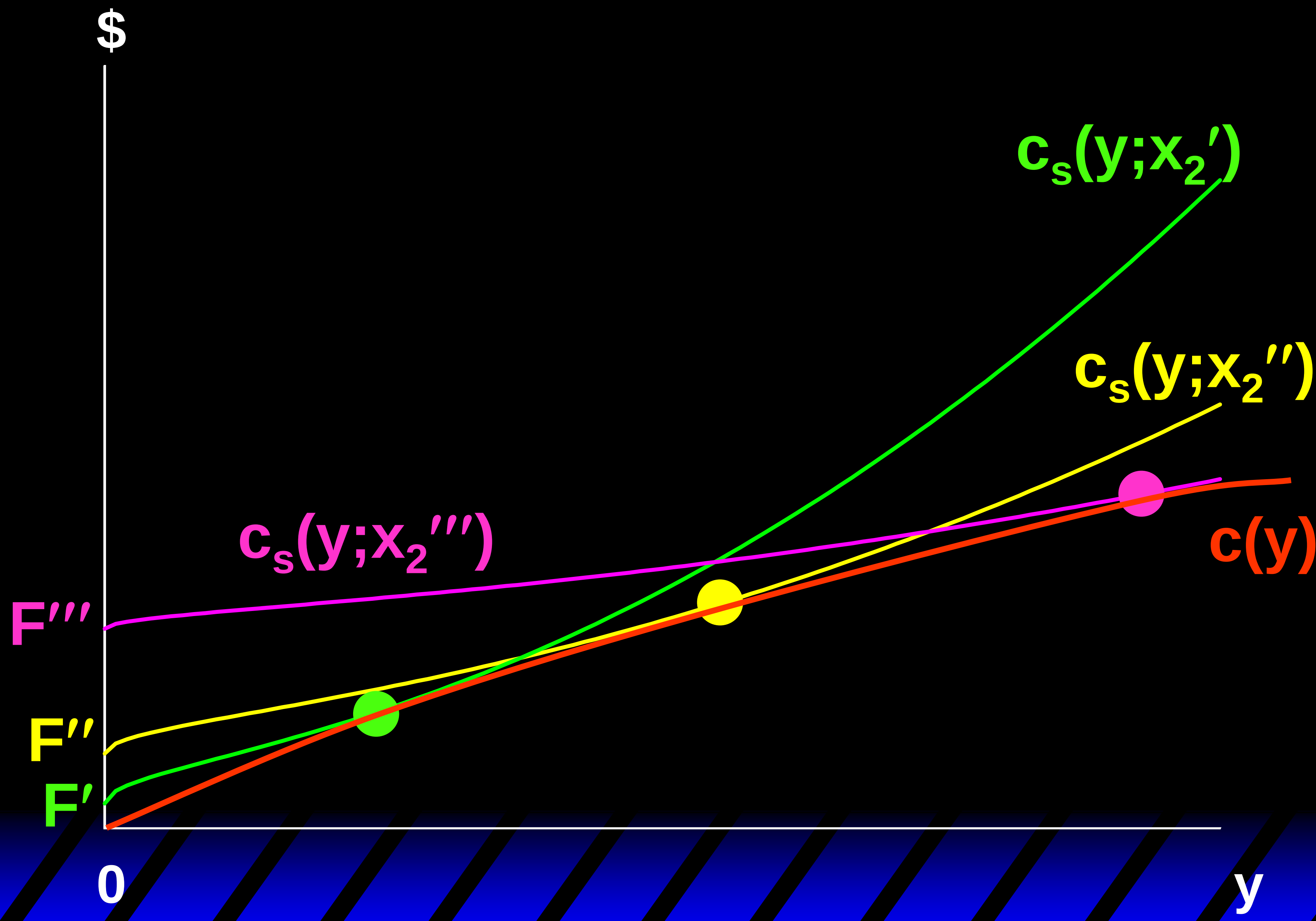
**The firm's long-run total cost curve consists of the lowest parts of the short-run total cost curves. The long-run total cost curve is the lower envelope of the short-run total cost curves.**

长期总成本曲线是短期总成本曲线的下包络线。

# Short-Run & Long-Run Total Cost Curves

If input 2 is available in **continuous** amounts then there is an infinity of short-run total cost curves but the long-run total cost curve is still the lower envelope of all of the short-run total cost curves.

不变要素的数量是连续的时候，有无数条短期总成本曲线。每一条都位于长期总成本曲线之上、并恰好相交于一点。(Lec 12)


$
$c_s(y;x_2')$
$c_s(y;x_2'')$
$c_s(y;x_2''')$
$c(y)$
$F'''$
$F''$
$F'$
0
y

# Short-Run & Long-Run Average Total Cost Curves

**For any output level y, the long-run total cost curve always gives the lowest possible total production cost.**

给定任意一个y，每一种短期情境都对应一个总成本；在长期，厂商选择使生产y的总成本最低的那个短期情境。

# Short-Run & Long-Run Average Total Cost Curves

- Therefore, the long-run av. total cost curve must always give the lowest possible av. total production cost.

换句话说，给定任意一个y，每一种短期情境都对应一个平均成本；在长期，厂商选择使生产y的平均成本最低的那个短期情境。

- The long-run av. total cost curve must be the lower envelope of all of the firm’s short-run av. total cost curves.

由此可知，长期平均成本线也是短期平均成本线的下包络线。

# Short-Run & Long-Run Average Total Cost Curves

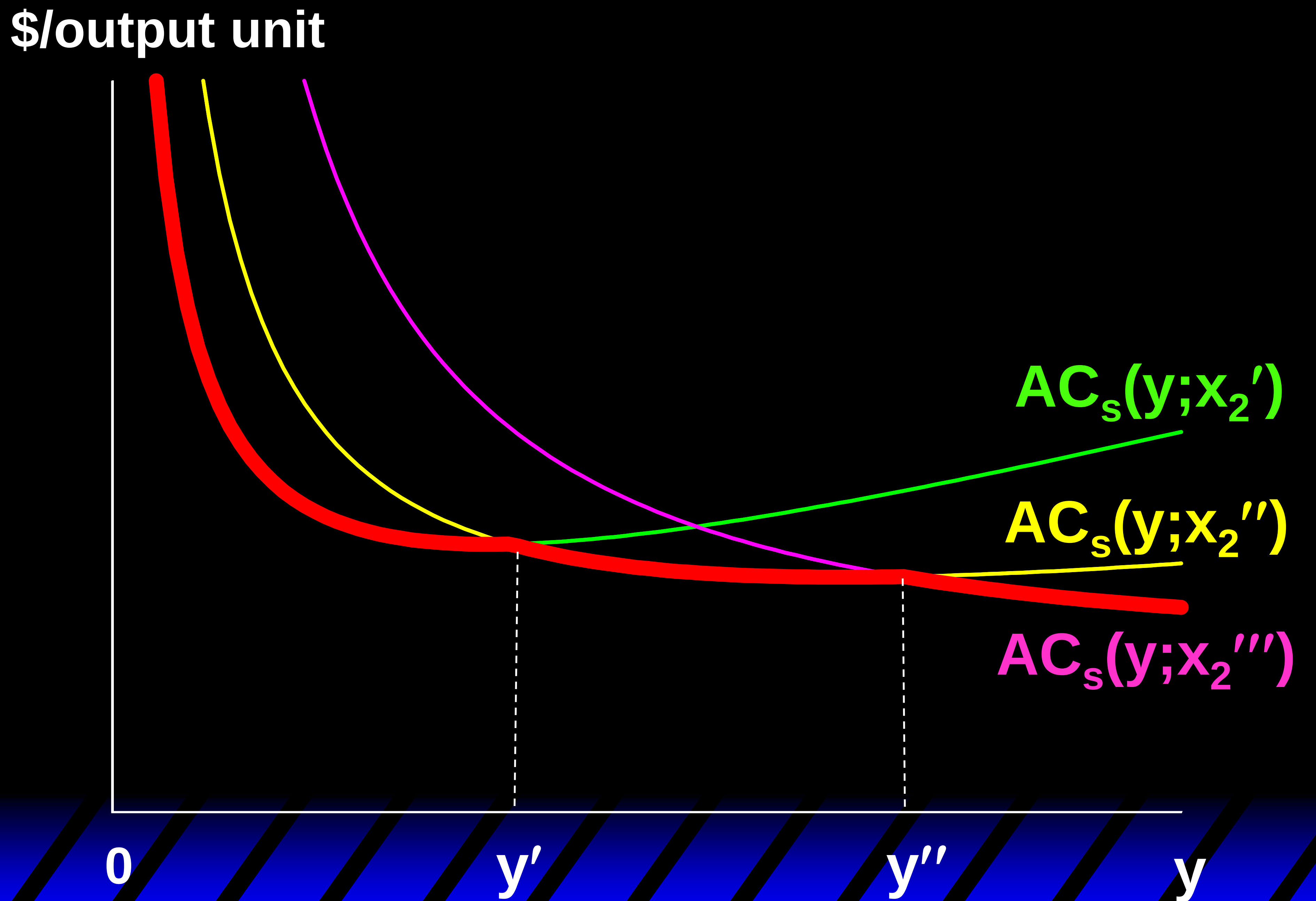
E.g. suppose again that the firm can be in one of just three short-runs;

$x_2 = x_2'$

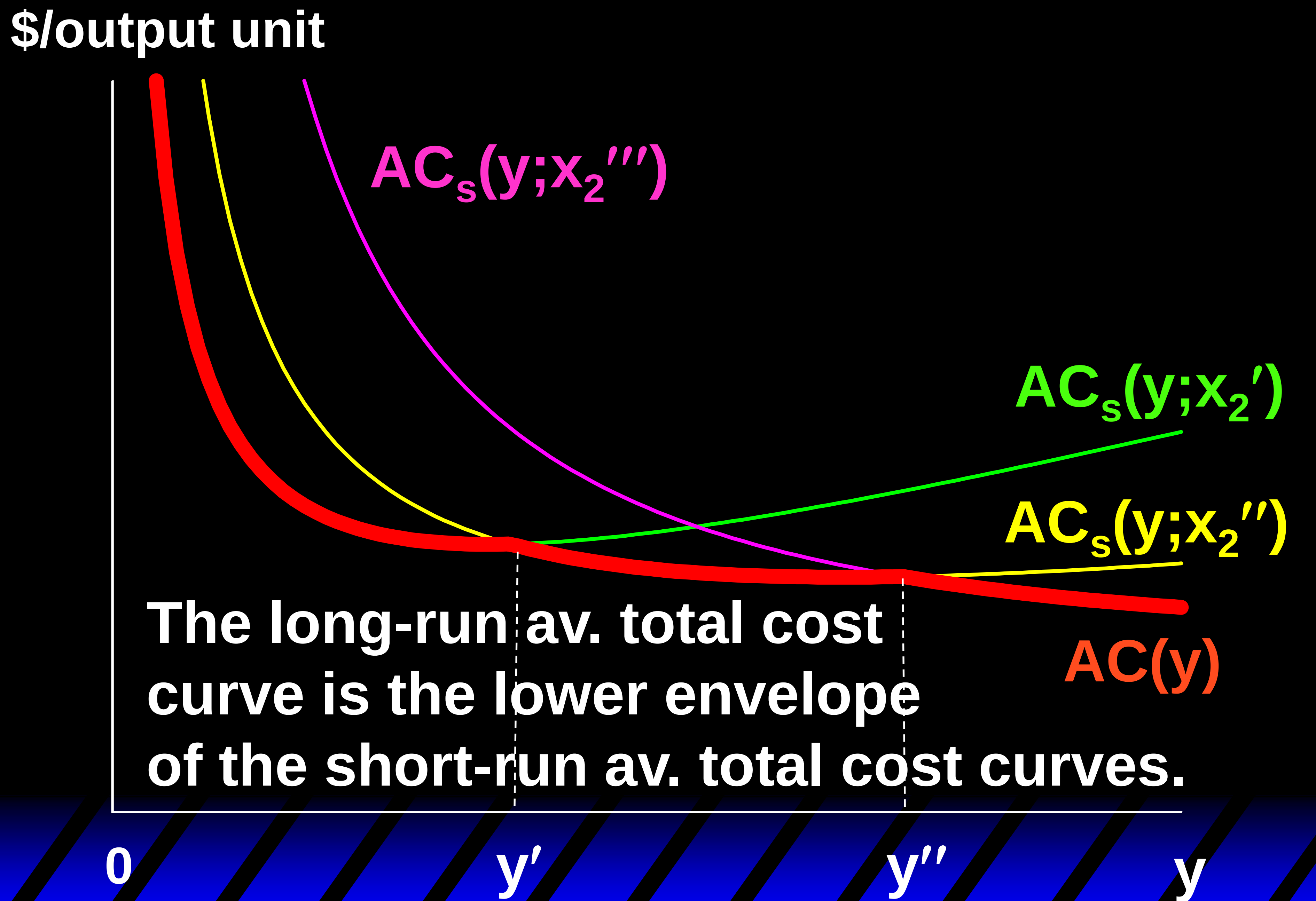
or $x_2 = x_2''$ $(x_2' < x_2'' < x_2''')$

or $x_2 = x_2'''$

then the firm's three short-run average total cost curves are ...



$/output unit
$AC_s(y;x_2')$
$AC_s(y;x_2'')$
$AC_s(y;x_2''')$
0
y′
y″
y




The long-run av. total cost curve is the lower envelope of the short-run av. total cost curves.

# Short-Run & Long-Run Marginal Cost Curves

**Q: Is the long-run marginal cost curve the lower envelope of the firm's short-run marginal cost curves?**

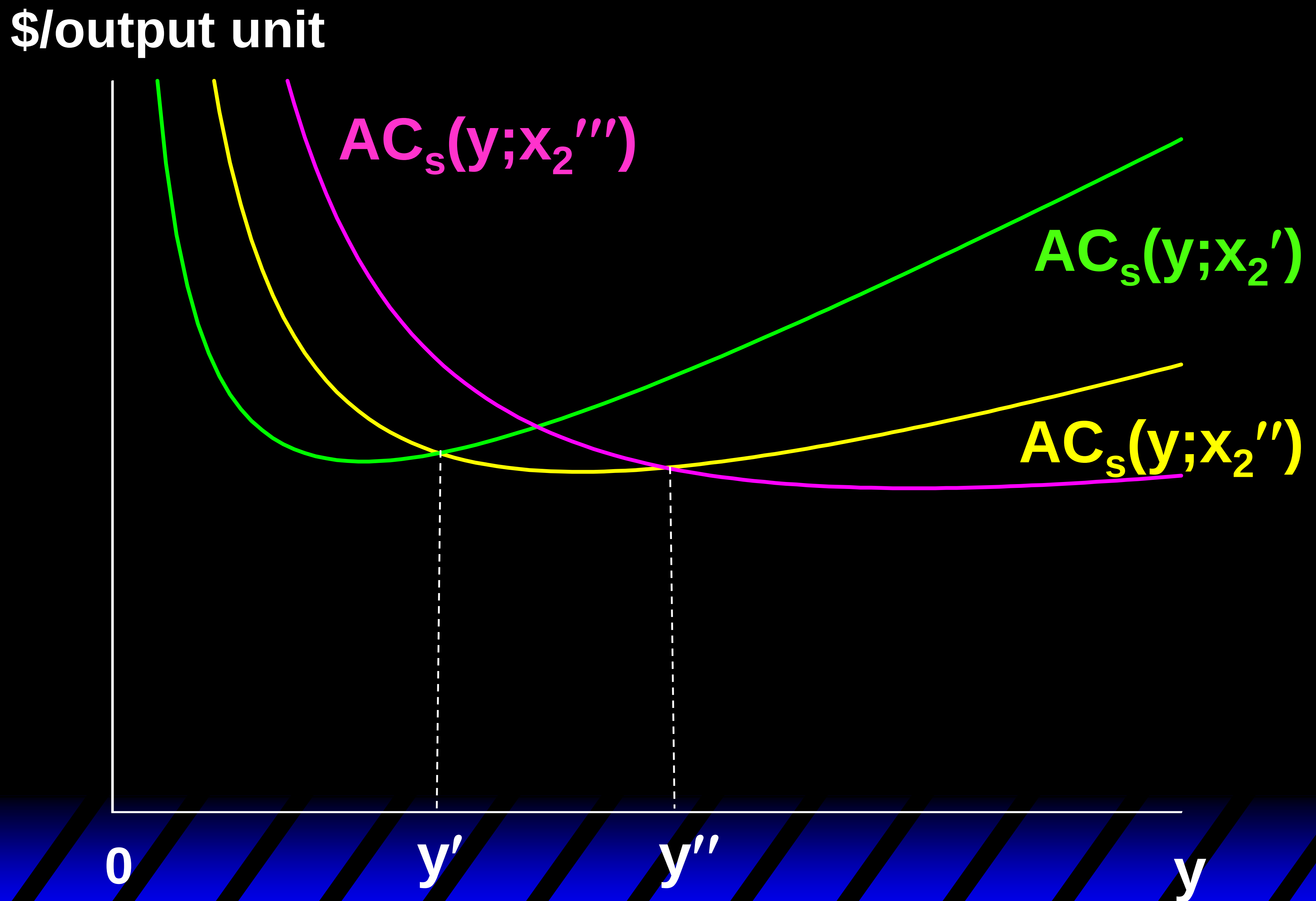
# Short-Run & Long-Run Marginal Cost Curves

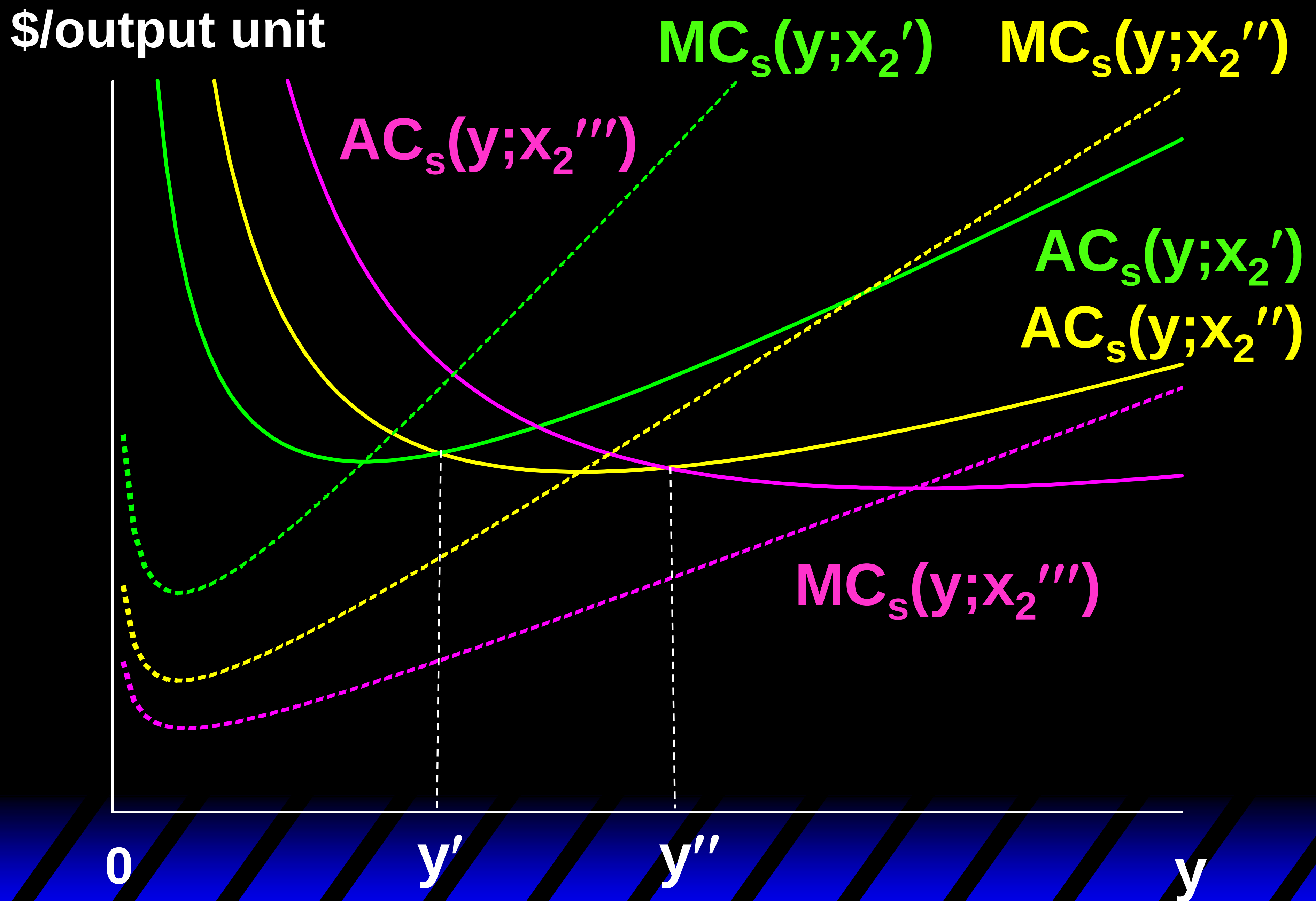
**Q: Is the long-run marginal cost curve the lower envelope of the firm’s short-run marginal cost curves?**

**A: No.**

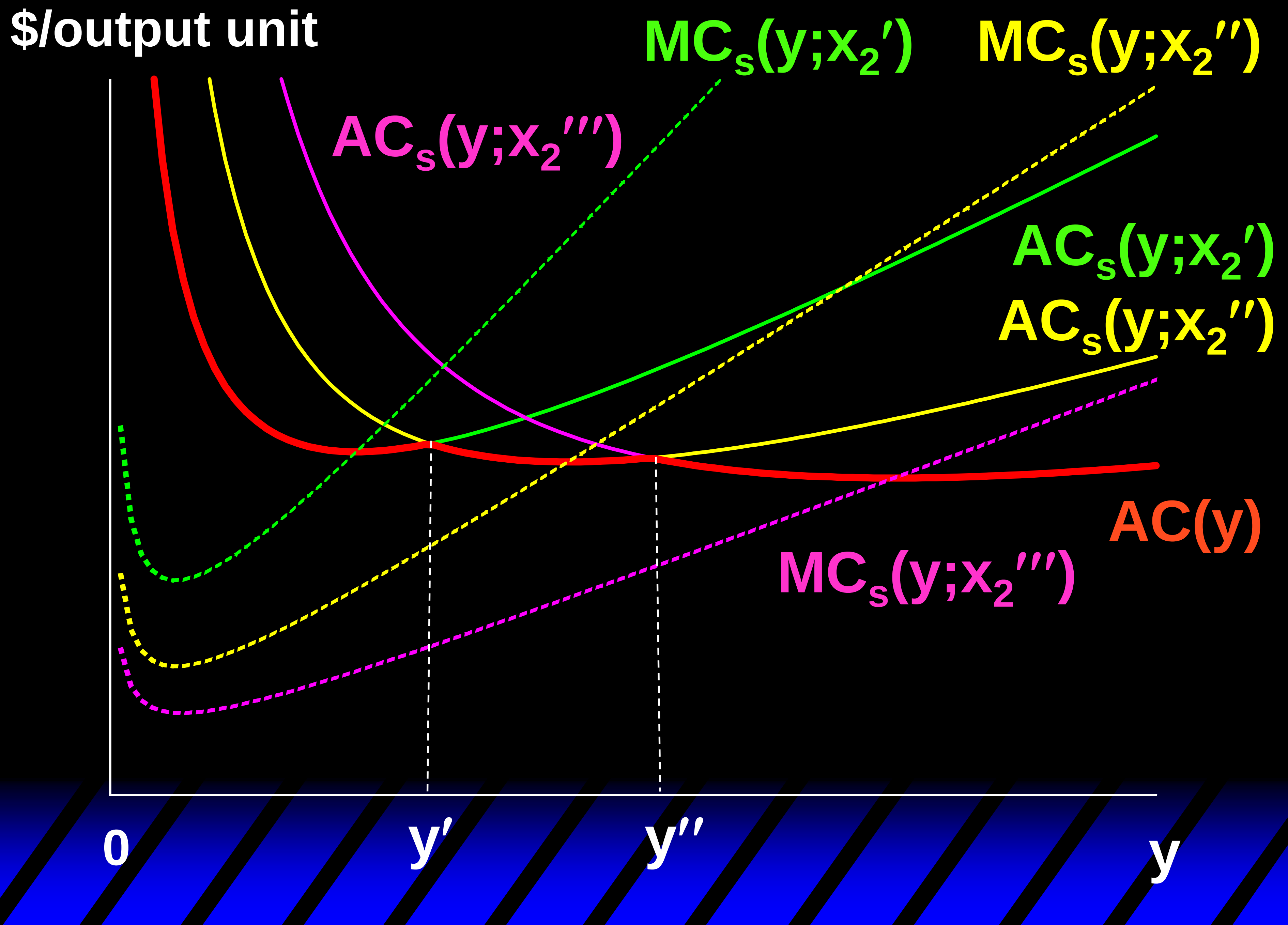
# Short-Run & Long-Run Marginal Cost Curves

**The firm's three short-run average total cost curves are ...**

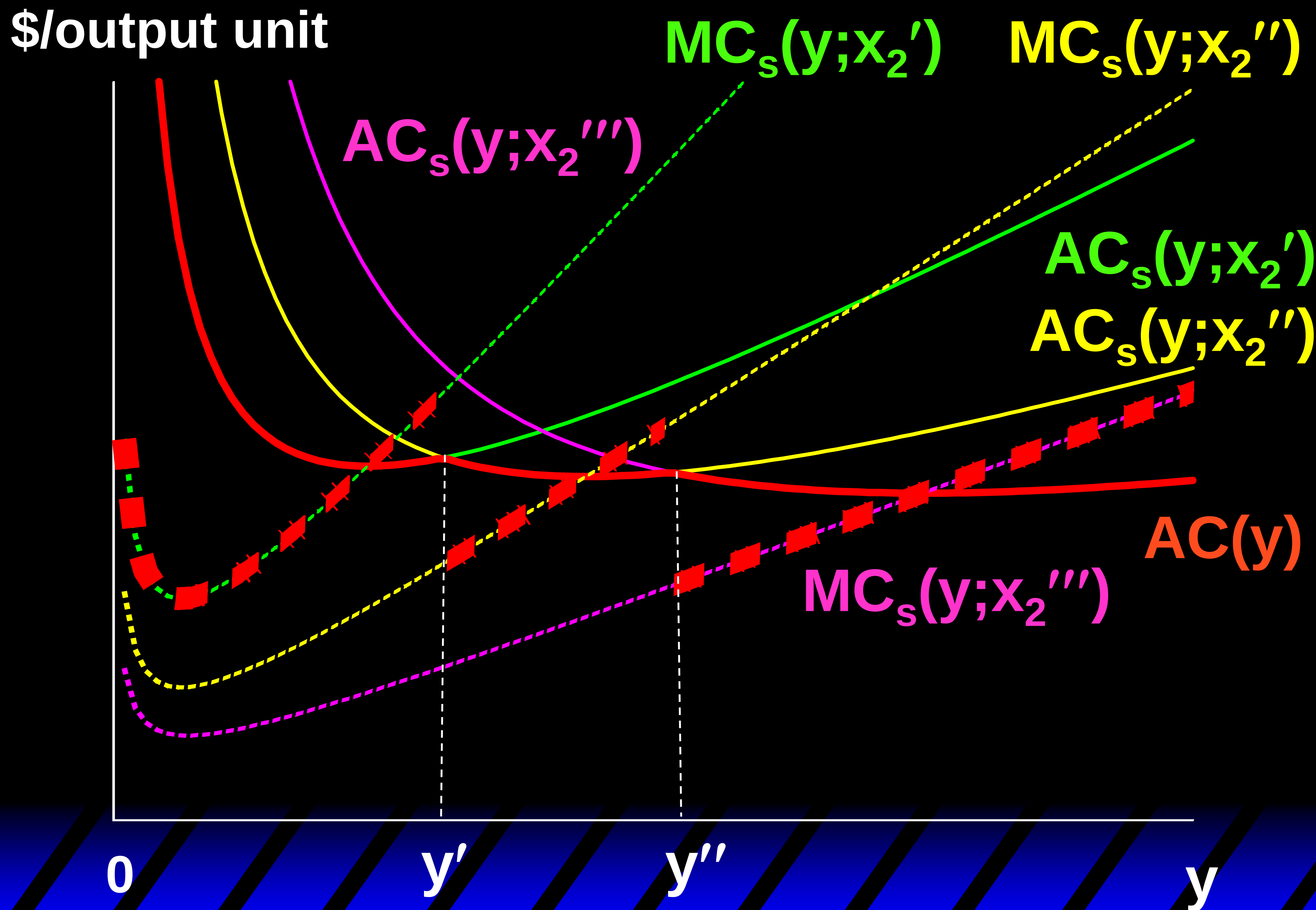

$/output unit
$AC_s(y;x_2''')$
$AC_s(y;x_2')$
$AC_s(y;x_2'')$
0
y′
y″
y



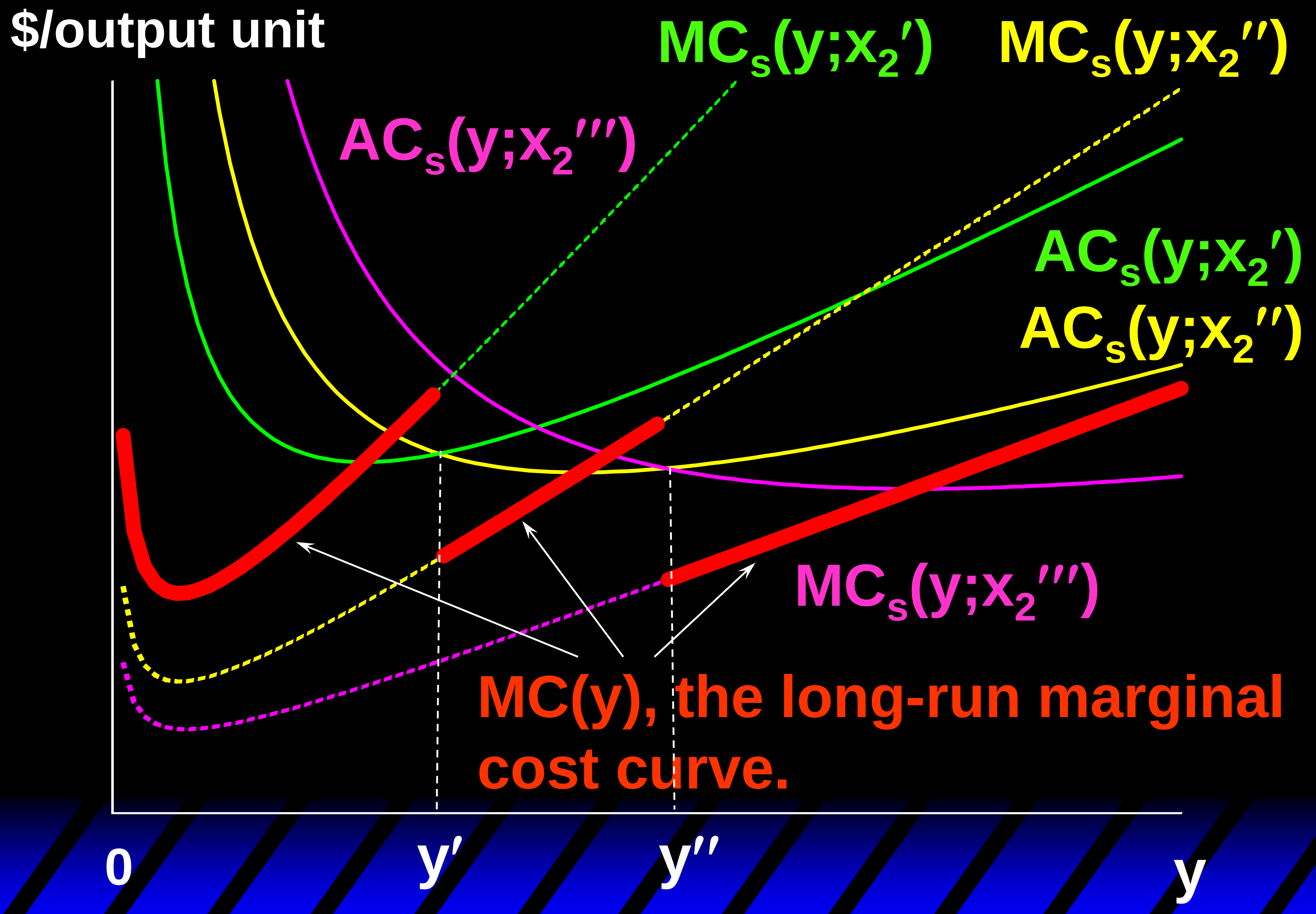
$/output unit
$MC_s(y;x_2')$
$MC_s(y;x_2'')$
$AC_s(y;x_2''')$
$AC_s(y;x_2')$
$AC_s(y;x_2'')$
$MC_s(y;x_2''')$
0
y′
y″
y



$/output unit
$MC_s(y;x_2')$
$MC_s(y;x_2'')$
$AC_s(y;x_2''')$
$AC_s(y;x_2')$
$AC_s(y;x_2'')$
$AC(y)$
$MC_s(y;x_2''')$
0
y′
y′′
y



$/output unit
$MC_s(y;x_2')$
$MC_s(y;x_2'')$
$AC_s(y;x_2''')$
$AC_s(y;x_2')$
$AC_s(y;x_2'')$
$AC(y)$
$MC_s(y;x_2''')$
0
y′
y″
y



$/output unit
$MC_s(y;x_2')$
$MC_s(y;x_2'')$
$AC_s(y;x_2''')$
$AC_s(y;x_2')$
$AC_s(y;x_2'')$
$MC_s(y;x_2''')$
MC(y), the long-run marginal cost curve.
0
y′
y″
y

# Short-Run & Long-Run Marginal Cost Curves

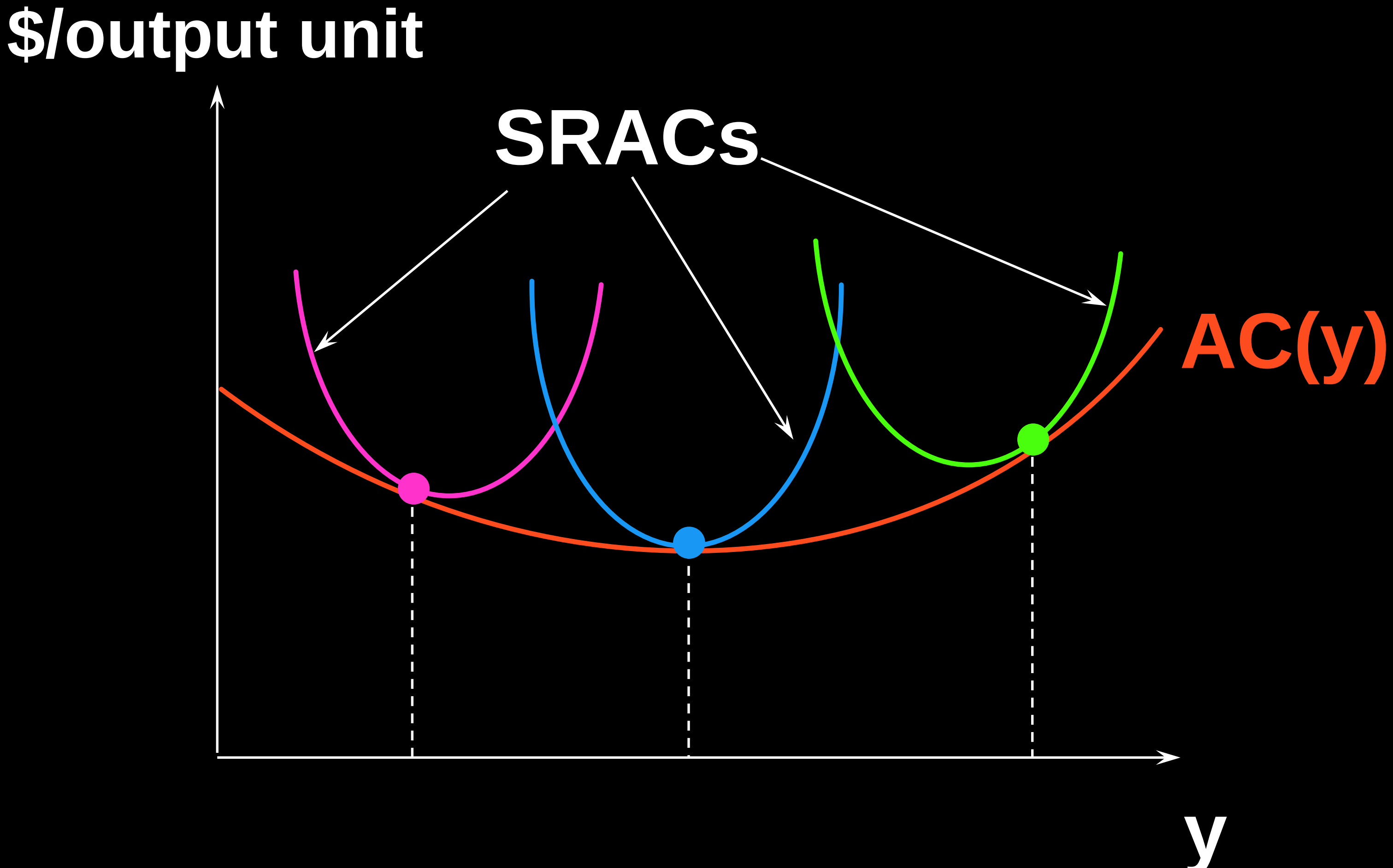
- For any output level y > 0, the long-run marginal cost is the marginal cost for the short-run chosen by the firm (任意产量水平处的长期MC都是企业选定的最优短期情境下的MC).
- This is always true, no matter how many and which short-run circumstances exist for the firm.

# Short-Run & Long-Run Marginal Cost Curves

**So for the continuous case, where $x_2$ can be fixed at any value of zero or more, the relationship between the long-run marginal cost and all of the short-run marginal costs is ...**

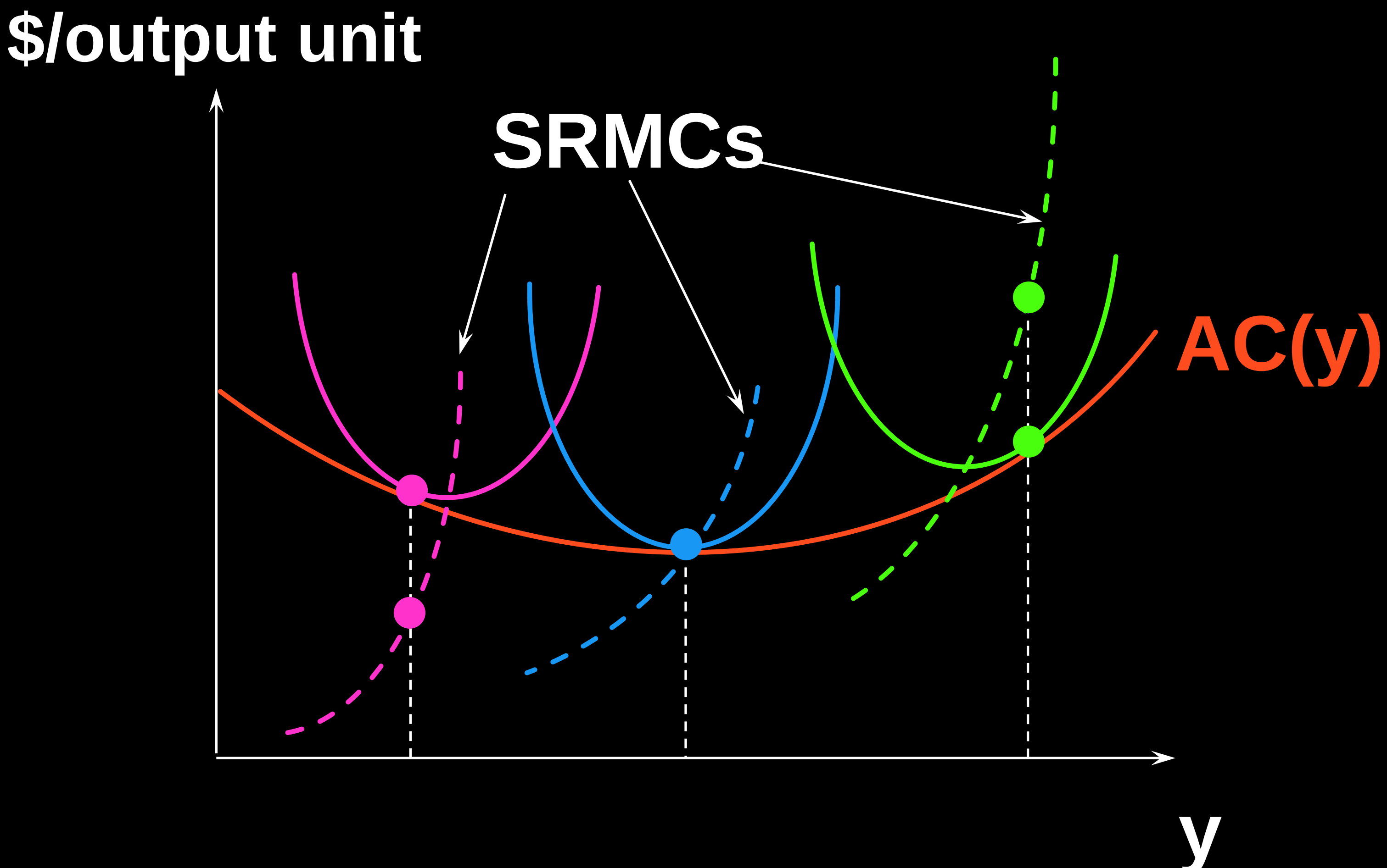
在连续情况下，长期平均成本线、边际成本线和短期平均成本线、边际成本线的关系如下：

# Short-Run & Long-Run Marginal Cost Curves



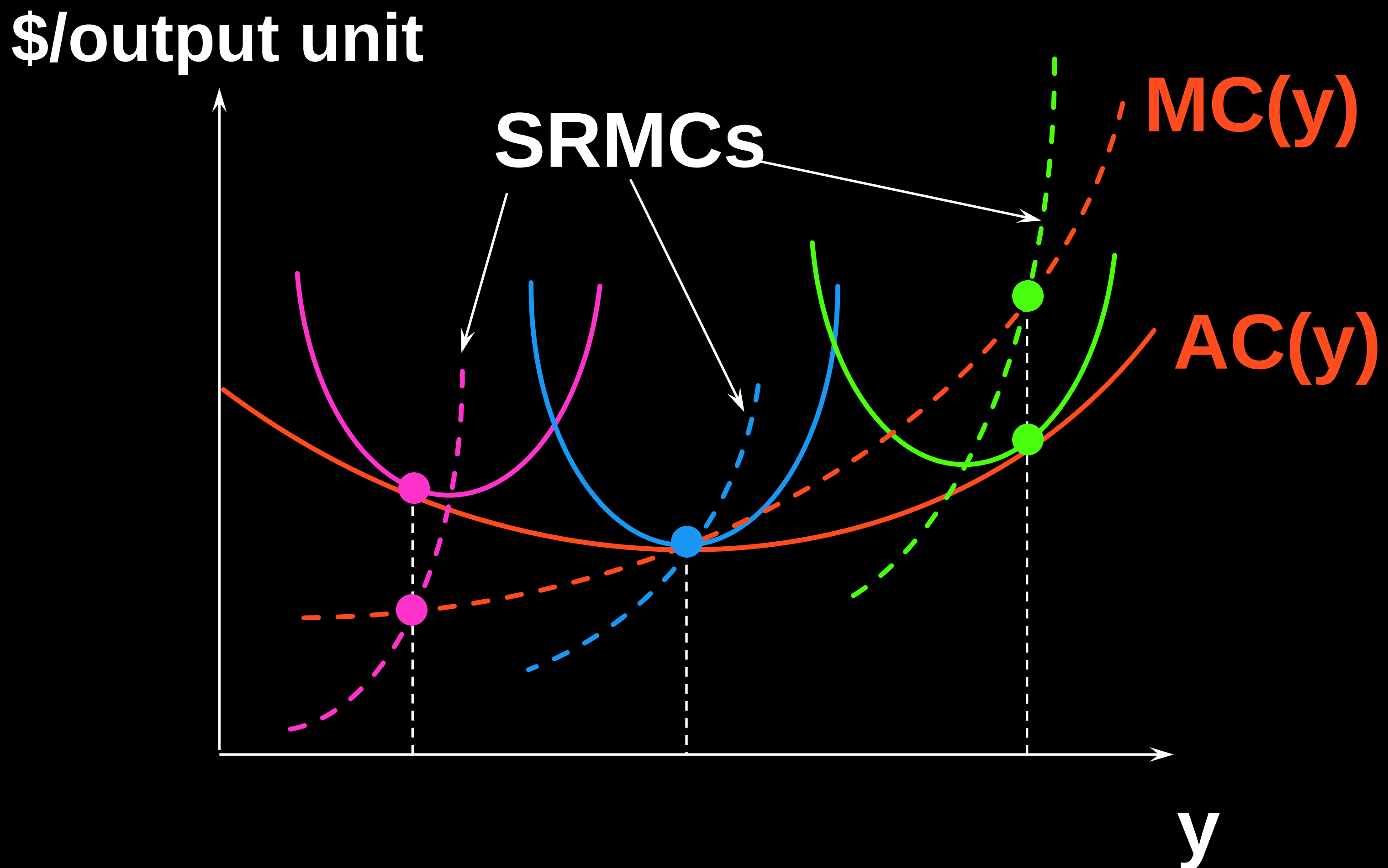

每条短期平均成本线都与长期平均成本线相切于一点

# Short-Run & Long-Run Marginal Cost Curves




每个切点对应的MC即长期MC

# Short-Run & Long-Run Marginal Cost Curves




For each y > 0, the long-run MC equals the MC for the short-run chosen by the firm.